PMAC PRINCE MAHIDOL AWARD CONFERENCE 2025

E-ISSN 2228-8082
Volume 77, Number 6, June 2025

SMJ

Siriraj Medical Journal

The world-leading biomedical science of Thailand

MONTHLY

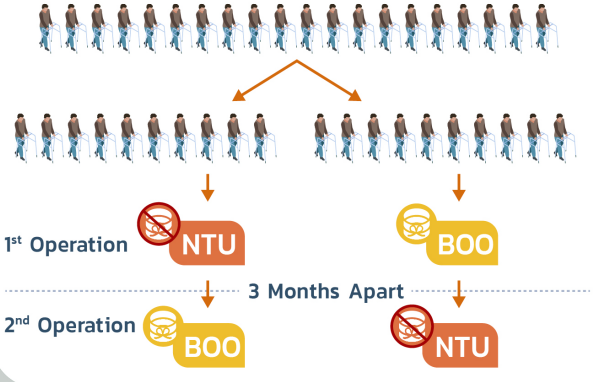
ORIGINAL ARTICLE

Postoperative Pain and Blood Loss of Non-use Compared to Partial-use of a Tourniquet in Bilateral Total Knee Replacement: A Randomized-Control Trial

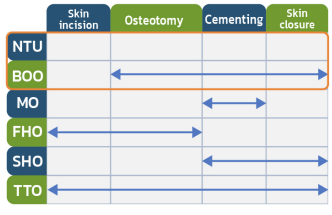
Performing total knee arthroplasty (TKA) without using a tourniquet, can reduce particularly the magnitude difference in pain and postoperative wound complications better than using the tourniquet as well as lack of significant differences in blood loss.

"Cross over RCT Design"

20 patients
with bilateral severe OA knee



6 Techniques
of tourniquet use in TKA.
We aim to compare 2 techniques.



NTU: No-tourniquet usage in operation
BOO: Before osteotomy in operation
MO: Mid-way into the operation
FHO: During the first half of operation
SHO: During the second half of operation
TTO: Throughout the operation

Results and Conclusion

	NTU	BOO
Pain	↓	↑
Blood loss	↔	↔
Postoperative complication	↓	↑
Operative time	↔	↔

The conclusion from this crossover **RCT** is that **NTU** provides better pain relief compared to **BOO**. The **NTU** group did not experience more blood loss than the **BOO** group, and the **BOO** group had one serious complication (**DVT**), and four wound complications (ecchymosis).

SCAN FOR FULL TEXT

SMJ SIRIRAJ MEDICAL JOURNAL | Wipatasinlapin, et al. *Siriraj Med J* 2025;77(6):419-426.

Indexed by Scopus® DOAJ

https://he02.tci-thaijo.org/index.php/sirirajmedj/index
E-mail: sijournal92@gmail.com

SMJ
Siriraj Medical Journal
The world-leading biomedical science of Thailand
Volume 77 Number 6
June 2025

ORIGINAL ARTICLE

SIRIRAJ MEDICAL JOURNAL

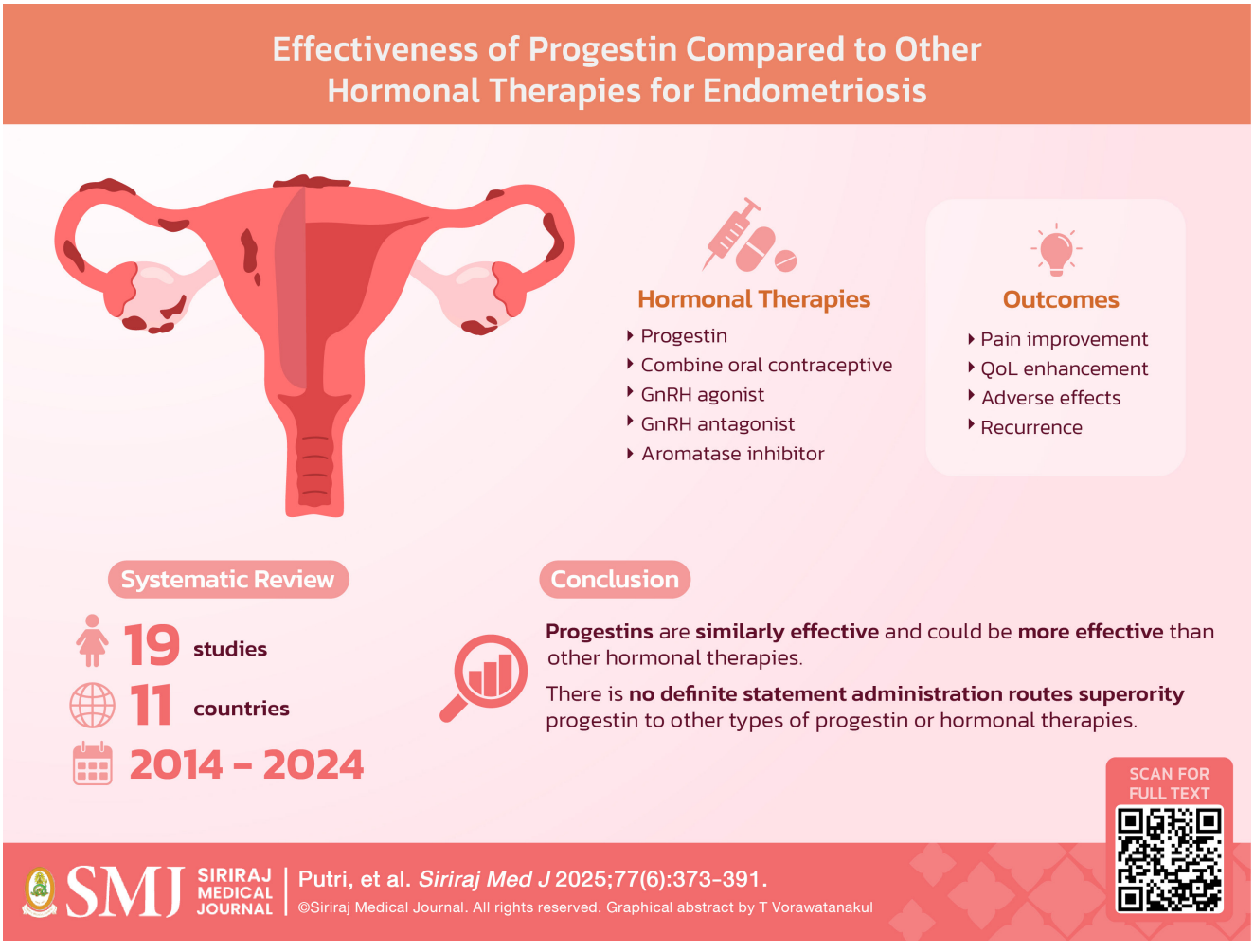
https://he02.tci-thaijo.org/index.php/sirirajmedj/index

Office: His Majesty the King's 80th Birthday Anniversary 5th December 2007 Building (SIMR), 2nd Fl., Room No.207
Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand
E-mail: sijournal92@gmail.com

Effectiveness of Different Progestin Modalities Compared to Other Hormonal Therapies for Endometriosis: A Systematic Review

Siti Azira Putri, B.M.[1], Raissa Nurwany, M.D., OBGYN[2,*], Iche Andriyani Liberty, Ph.D.[3]

[1]Medical Profession Education Program, Faculty of Medicine, Sriwijaya University, Palembang, Indonesia, [2]Department of Obstetrics and Gynecology, Sriwijaya University, Palembang, Indonesia, [3]Department of Public Health and Community Medicine, Sriwijaya University, Palembang, Indonesia.



**Corresponding author: Raissa Nurwany*
E-mail: raissa.nurwany@fk.unsri.ac.id
Received 18 November 2024 Revised 22 January 2025 Accepted 27 January 2025
ORCID ID: http://orcid.org/0009-0004-5884-7455
https://doi.org/10.33192/smj.v77i6.272256

ABSTRACT

Objective: A systematic review was conducted with a study compilation of women with endometriosis in determining the evidence of the use of various progestin modalities compared to other hormonal therapies in improving endometriosis-associated pain, enhancing quality of life (QoL) and minimizing adverse effects and recurrence of disease.

Materials and Methods: This review carried out search strategies on various searching databases to analyze all comparisons of various progestin-only therapies with each other, other types of hormonal therapies, and placebo. The primary outcome is improvement of endometriosis-associated pain. Meanwhile, the secondary outcomes are the impact on QoL or treatment satisfaction, adverse effects, and disease recurrence.

Results: Progestogen (including progestin-only contraceptives) combined oral contraceptives (COC), gonadotropin-releasing hormone (GnRH) agonists, and antagonists are the hormonal therapies that were included in this study. These hormonal therapies significantly decrease the symptoms and increase the patient's QoL, particularly dienogest, the most used progestogen in the study. The recurrence of the disease was mentioned when progestin-only contraceptives were compared to each other, GnRH agonists and antagonists, which were similar. In addition, almost all of the studies mentioned that irregular bleeding was the most commonly observed adverse effect.

Conclusion: Progestin-only contraceptives are similarly effective and could be more effective than other hormonal therapies in decreasing endometriosis-related symptoms, improving QoL, recurrence rate and minimizing adverse effects. This study also concludes that there is no definite statement on the superiority of specific kinds or administration routes of progestogen to other types of progestin or hormonal therapies.

Keywords: Endometriosis; progestin; hormonal therapy (Siriraj Med J 2025; 77: 373-391)

INTRODUCTION

Endometriosis is a chronic hormone-dependent gynaecological disorder that can be distinguished by the growth and appearance of similar histological components of endometrial glands (epithelial and stromal) outside the anatomical cavity of the uterine. This prevalence of endometriosis in women of reproductive age is approximately 10-15%, although it can rise as high as 70% among women with chronic pelvic pain (CPP).[1] The most common clinical manifestations are persistent pelvic pain and impaired fertility. Intermenstrual haemorrhage, dysmenorrhea, and dyspareunia, along with bowel and bladder symptoms such as dyschezia and dysuria, can also present as symptoms of endometriosis.[2]

Nowadays, there are specific options for treating symptomatic endometriosis, including hormonal therapies, surgical intervention, or a combination of both.[3,4] The approach to treating endometriosis requires an individualized-based therapy based on personal preference, efficacy, severity of symptoms, adverse effects, costs, and availability to determine an efficient treatment method. Therefore, hormonal therapy is one of the most frequent and recommended treatments because it suppresses menstruation and ovulation in order to control the disease and clinical manifestations. In endometriosis, hormonal therapy works by disrupting the menstruation cycle in the deactivation of the hypothalamus-pituitary ovary axis by causing a pseudo-decidual state with consequent amenorrhea, which in turn prevents the progression of the disease.[2,5]

According to the European Society of Human Reproduction and Embryology (ESHRE) guidelines, progestogen or progestin is a recommended first-line choice of hormonal therapy for endometriosis.[4] Progestin has multiple mechanisms in progesterone receptors that induce beneficial effects in reducing the progression of endometriosis and relieving pain.[5] This therapy has many options of modalities for patients, so it can be convenient for women with endometriosis who prefer not to worry about daily pill-taking or monthly injections. Also, it is suitable for women with estrogen tolerance due to its side effects and health risks. The most common adverse effects include irregular uterine bleeding, mood swings, weight gain, and decreased density of bone. However, progestin has a lower incidence of side effects than other hormonal therapies and rarely causes treatment abandonment. Approximately two-thirds of patients are satisfied as their symptomatic endometriosis improves to some extent.[4]

The available progestins that can be administered to patients include oral, intramuscular, subcutaneous, or intrauterine routes. Although there are many different types of progestin, the most frequent progestins that are utilized are dienogest (DNG), norethindrone acetate (NETA), which

is available in the oral route, and medroxyprogesterone acetate (MPA), which is administered via oral, intramuscular, and subcutaneous.[2,4] However, as time passes, the excess kinds of progestins have various outcomes in the therapy in treating endometriosis. Furthermore, the necessity of providing better evidence must be attempted. Therefore, this systematic review aims to evaluate the efficacy of various progestin modalities for treating endometriosis. It compares these treatments with other hormonal therapies in reducing symptoms, minimizing adverse effects, and preventing recurrence.

MATERIALS AND METHODS

Literature search

A systematic review of the efficacy of different progestin modalities compared to other therapies in women with endometriosis was conducted using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria. The relevant articles were selected through a search in PubMed, Cochrane, Science Direct and Google Scholar. We apply keywords such as "Endometriosis OR Endometrium Ectopic" AND "Progestin OR Progestogen." The database search was made in March 2024 and included articles from 1 January 2014 to 29 February 2024.

Study selection

The inclusion requirements for this systematic review are randomized controlled trials (RCTs), clinical trials, retrospectives, and observational studies that used progestin modalities compared to other progestin therapies, hormonal therapies, placebos, or without treatment. We selected studies that involved women with surgery-based diagnosis (with or without histopathologic confirmation) and validated radiology-based diagnosis by magnetic resonance or ultrasound of endometriosis. The primary outcome is the improvement of endometriosis-associated pain or symptoms. In addition, the secondary outcomes are the impact on quality of life (QoL), adverse effects, and disease recurrence. Meanwhile, the excluded criteria for this systematic review are non-fully accessible articles, non-English articles, and other study methods not mentioned in the inclusive criteria. The results of assessing the database will be extracted into an extraction table. (Table 1)

Data extraction

The included studies will be extracted to obtain data as follows: (1) Author's name, year of study, country (2) Type of progestin therapy (3) Study design (4) Diagnosis method of endometriosis (4) Type of intervention comparator (5) Result of study (6) Included participant (7) Evaluated outcome.

Risk of Bias Analysis

The Cochrane Collaboration's Risk of Bias Assessment Tool assessed the risk of bias analysis from the included study in the Review Manager 5 application. The overall quality was moderate. The risk of bias assessment was examined by each study's risk of bias and the overall percentage of each risk of bias component judgment, as shown below.

RESULTS

The predetermined search term identified 367 references published from 1 January 2014 to 29 February 2024. After checking for duplicates, 193 references were removed so that 111 references would be screened for their eligibility. Eighty references were excluded from being included because the studies could not be accessed. These 19 studies fulfilled the inclusion criteria. Fifty-five studies were excluded for the following reasons: irrelevant population, unrelated interventions, different outcomes measured, and incomplete data. (Fig 1)

Progestin, compared to other progestin therapies

In a study conducted by Lee et al., it evaluated dienogest (DNG), levonorgestrel-releasing intrauterine system (LNG-IUS), and untreated women with laparoscopically confirmed endometriosis. Endometriosis-associated pain was significantly lower in the DNG and LNG-IUS than in the untreated group, where the VAS scores were not significantly different after 6- and 12-month interventions. The rate of endometriosis recurrence was higher in the untreated group than in the treated group. Meanwhile, the side effects of both interventions are not substantially different between DNG and LNG-IUS. The most frequent adverse reaction was vaginal bleeding, which is self-limited in most patients.[6]

Carvalho et al evaluated the efficacy of etonogestrel (ENG)-releasing contraceptive implant compared to LNG-IUS in surgical and histopathological diagnosed endometriosis. Dysmenorrhea and noncyclic pelvic pain were significantly reduced in both groups with no statistical difference from each other. There was an improvement in the patient's QoL in both groups, but the difference was not shown significantly.[7]

Meanwhile, a clinical trial that Vahid-Dastjerdi carried out compared the effectiveness of two oral progestins, DNG and medroxyprogesterone acetate (MPA), in surgically confirmed endometriosis. The reduction of pelvic pain was significantly different in contrast to dysmenorrhea

TABLE 1. Summary and results of the included study.

Author, Year, Country	Progestin Therapy	Type of Study	Type of Diagnosis	Comparator	Participants Included	Outcome Evaluated				Result
						Pain	QoL	Recurrence	Adverse Effects	
Progestin vs Progestin										
KH Lee *et al.*, 2018, South Korea.	Dienogest 2 mg / Oral	Retrospective Cohort	Surgical	52-mg 20-mg/d LNG-IUS and no treatment	130 vs 72 vs 83	Yes		Yes	Yes	- The VAS score reduction of pain in dienogest, LNG-IUS, and untreated groups significantly differed after 6 and 12 weeks ($p = 0.004$ and $p = 0.001$, respectively). - The recurrence incidence between dienogest (3.8%), LNG-IUS (9.7%) and untreated groups (32.5%) was significantly different ($p = 0.001$). - There was an unnoticeable difference ($p = 0.381$) in the side effects rate between dienogest (36.9%) and LNG-IUS (29%). - The most observed side effect was vaginal bleeding.
Carvalho, N *et al.*, 2018, Brazil.	Etonogestrel / Implant	Randomized Clinical Trial	Surgical + Histopatho-logical	52-mg 20-mg/d LNG (IUS)	52 vs 51	Yes	Yes			- The VAS score of noncyclic pain and dysmenorrhea reduced significantly in both groups after 180 days. ($p < 0.001$). - There were no significant differences in the mean VAS score of noncyclic pelvic pain and dysmenorrhea of both treatments after 180 days. ($p = 0.241$ and $p = 0.431$, respectively). - The quality of life's assessment showed substantial improvement in all the domains of the core and modular segments of the EHP-30 questionnaire in both treatment groups ($p < 0.05$), with no statistical differences between them ($p > 0.05$).

TABLE 1. Summary and results of the included study. (Continue)

Author, Year, Country	Progestin Therapy	Type of Study	Type of Diagnosis	Comparator	Participants Included	Outcome Evaluated				Result
						Pain	QoL	Recurrence	Adverse Effects	
Vahid-Dastjerdi, M *et al.*, 2023, Iran	Dienogest 2 mg / Oral	Randomized Clinical Trial	Surgical	10 mg MPA (Oral)	48 vs 53	Yes		Yes	Yes	- The measured endometriosis-related pain was significantly lower in the dienogest group than in the MPA group ($p < 0.001$). - The recurrence incidence of endometriosis between both groups was not different statistically ($p = 0.4$). - The drug-related side effects were significantly different between both groups ($p < 0.001$).
Progestin vs Combined Oral Contraceptive (COC)										
Kashi, A.M *et al.*, 2021, Iran	Dienogest 2 mg / Oral	Randomized Double-Blinded Clinical Pilot	Surgical	EE 30 µg + Levonorgestrel 0.3 mg (Oral) and Placebo	30 vs 30 vs 20	Yes	Yes		Yes	- The VAS score between dienogest and COC showed significantly lower scores for pelvic pain ($p = 0.026$) and dyspareunia ($p = 0.04$) than the placebo group. Meanwhile, there was no meaningful difference for dysuria ($p = 0.378$) and dyschezia ($p = 0.547$). - There was a consequential difference in the overall quality of life score ($p = 0.001$). - The treatment-related side effects were spotting, hair loss, headache, nausea, hot flashes, backache, hand numbness, and skin dryness, with no significant difference between the three groups

TABLE 1. Summary and results of the included study. (Continue)

Author, Year, Country	Progestin Therapy	Type of Study	Type of Diagnosis	Comparator	Participants Included	Outcome Evaluated				Result
						Pain	QoL	Recurrence	Adverse Effects	
Caruso, S *et al.*, 2022, Italy	Dienogest 2 mg / Oral	Randomized Clinical Trial	Radiological	1.5 mg 17b-estradiol / E2 and 2.5 mg Nomegestrol acetate / NOMAC (Oral)	98 vs 99	Yes	Yes			- Pain improvement was assessed by the CPP VAS score that was statistically meaningful ($p < 0.001$) until 12 months of follow-up. - The significant improvement of CPP ($p <0.01$), dysmenorrhea ($p = 0.02$), and dyspareunia ($p = 0.003$) between both groups was shown at the 6 months of follow-up. - The overall quality of life score in the dienogest group had better SF-36 somatic ($p < 0.01$) and FSFI scores ($p < 0.006$) than women on E2/NOMAC after 6 and 12 months of treatment
Niakan, G *et al.*, 2021, Iran	Dienogest 2 mg / Oral	Randomized Clinical Trial	Surgical	EE 30 µg + Levonorgestrel 0.3 mg (Oral) and Placebo	30 vs 30 vs 30	Yes	Yes		Yes	- The VAS score of dyspareunia was not substantially different after 3 months of treatment ($p =0.11$). - The pelvic pain symptoms were significantly reduced ($p =0.003$), while dysuria and dyschezia were not significantly reduced ($p = 0.81$, $p = 0.67$, respectively) after 3 months of treatment. - The overall quality of life score was statistically different between the control and dienogest ($p = 0.02$) and COC ($p = 0.001$) but not statistically different between intervention groups. - The observed drug-related side effects were spotting, hair loss, headache, nausea, hot flashes, backaches, numbness, and skin dryness, which were not statistically meaningful between the three groups ($p > 0.05$).

TABLE 1. Summary and results of the included study. (Continue)

Author, Year, Country	Progestin Therapy	Type of Study	Type of Diagnosis	Comparator	Participants Included	Outcome Evaluated				Result
						Pain	QoL	Recurrence	Adverse Effects	
Piacenti, I *et al.*, 2021, Italy	Dienogest 2 mg / Oral	Prospective Cohort Study	Surgical + Histopatho-logical or Radiological	EE 0,02 mg + Levonogestrel 0.1 mg (Oral)	43 vs 43	Yes	Yes		Yes	- Dienogest significantly reduced CPP ($p = 0.002$) and dyspareunia ($p = 0.021$). Meanwhile, COC significantly reduced dyspareunia ($p =. 0.023$). - The physical component quality of life scoring was substantially improved in the dienogest and COC groups ($p < 0.0001$, $p < 0.034$, respectively). Meanwhile, the mental component scoring was only substantially improved in the dienogest group ($p < 0.0001$). - The most common side effect in both groups was vaginal bleeding in the first 3 months of treatment ($p <0.001$).
Taha, LE *et al.*, 2021, Lebanon	Dienogest 2 mg / Oral	Randomized Clinical Trial	Surgical or Radiological	EE 0.03 mg and Drospirenone 3 mg (Oral)	25 vs 26	Yes	Yes		Yes	- Dienogest and COC significantly decreased the VAS score of endometriosis-related pelvic pain ($p <0.0001$), but there were no significant differences between both groups ($p = 0.111$). - Both groups have similar improved patient quality of life, which was statistically meaningful on the core question of pain. ($p < 0.001$). - Dienogest has fewer side effects than the COC.

TABLE 1. Summary and results of the included study. (Continue)

Author, Year, Country	Progestin Therapy	Type of Study	Type of Diagnosis	Comparator	Participants Included	Outcome Evaluated			Adverse Effects	Result
						Pain	QoL	Recurrence		
Progestin vs Gonadotropin-releasing Hormone Agonist (GnRH Agonist)										
Abdou, A M *et al.*, 2017, Egypt	Dienogest 2 mg / Oral	Randomized Clinical Trial	Surgical	Leuprolide Acetate 3.75 mg (Intra Muscular Injection)	121 vs 121	Yes			Yes	- The VAS score notably reduced pelvic pain, dyspareunia, and back pain (p = 0.000). - There was no statistically meaningful difference in VAS score reduction between both groups in pelvic pain (p = 0.170), dyspareunia (p = 0,263) and back pain (p = 0.597). - The most frequent side effect of the dienogest group was vaginal bleeding (64.5%) which was highly substantially different (p = 0.000) between the two groups. - The most frequent side effects of leuprolide acetate were hot flushes (46.3%), which was highly substantially different (p = 0.00) between the two groups. - Other observed side effects were vaginal dryness (p = 0.001), weight gain (p = 0.02), which was significantly different, and headache (p = 0.13), which was not significantly different between both groups.
Purwanto, J *et al.*, 2020, Indonesia	Dienogest 2 mg / Oral	Randomized Clinical Trial	Surgical	Leuprolide Acetate 3.75 mg (Intra Muscular Injection)	10 vs 10	Yes			Yes	- There was a significantly reduced VAS score in the dienogest and leuprolide acetate groups every four weeks of follow-up until 12 weeks (p = 0.004 and p = 0,003, respectively). However, both groups had a significant difference in VAS scores (p = 1.00). - The adverse effects of the treatment were vaginal dryness, joint pain, decreased libido, headaches, and hot flashes, which were substantially different between both groups (p = 0.238).

TABLE 1. Summary and results of the included study. (Continue)

Author, Year, Country	Progestin Therapy	Type of Study	Type of Diagnosis	Comparator	Participants Included	Outcome Evaluated				Result
						Pain	QoL	Recurrence	Adverse Effects	
Tang, M *et al.*, 2023, China	Dienogest 2 mg / Oral	Prospective Clinical Trial	Surgical	Leuprolide Acetate 3.75 mg (Intra Muscular Injection)	41 vs 40	Yes		Yes		- The VAS pain score showed improvement and was statistically meaningful between both groups after 3 and 6 months of treatment ($p < 0.05$). - The Kupperman score was statistically meaningful between both groups after 3 and 6 months of treatment ($p < 0.05$), which assessed the severity of symptoms. - The postoperative recurrence rate was eight patients in the dienogest group and two patients in the GnRH agonist group, significantly different between the two groups ($p < 0.05$).
Ceccaroni, M *et al.*, 2021, Italy	Dienogest 2 mg / Oral	Randomized Clinical Trial	Surgical	Leuprolide Acetate 3.75 mg (Intra Muscular Injection)	65 vs 81	Yes			Yes	- Dienogest and GnRH agonists reduced endometriosis-related pain significantly ($p < 0.001$). - There were several observed adverse effects, such as amenorrhea ($p = 0.05$) and hot flushes ($p < 0.001$), which were substantially different in GnRH agonist than dienogest. Meanwhile, spotting ($p < 0.001$) was substantially different in dienogest than GnRH agonist.
Ozaki, R *et al.*, 2020, Japan	Dienogest 2 mg / Oral	Prospective Clinical Trial	Surgical	Goserelin Acetate 1.8 mg (Subcutaneous Injection)	35 vs 35	Yes			Yes	- Dienogest reduced endometriosis-related pain more significantly than GnRH agonists ($p = 0.006$). - The side effect that occurred more significantly in GnRH agonists than dienogest was hot flashes ($p < 0.001$). - Breast pain and metrorrhagia were the side effects that occurred more significantly in dienogest than GnRH agonists ($p = 0.04$ and $p < 0.001$, respectively).

TABLE 1. Summary and results of the included study. (Continue)

Author, Year, Country	Progestin Therapy	Type of Study	Type of Diagnosis	Comparator	Participants Included	Outcome Evaluated				Result
						Pain	QoL	Recurrence	Adverse Effects	
Progestin vs Gonadotropin-releasing Hormone Antagonist (GnRH Antagonist)										
Carr, B *et al.,* 2014, USA.	MPA 104 mg/ 0.65 mL/ Subcutaneous Injection	Randomized Clinical Trial	Surgical	Elagolix 150 mg daily and Elagolix 75 mg twice a day	84 vs 84 vs 84	Yes			Yes	- There was a significantly reduced VAS score in the dienogest and leuprolide acetate groups every 4 weeks of follow-up until 12 weeks (p = 0.004 and p = 0,003, respectively). However, neither group had a notable VAS score difference (p = 1.00). - The adverse effects were vaginal dryness, joint pain, decreased libido, headaches, and hot flashes, which were not statistically meaningful between both groups (p = 0.238).
Progestin vs Aromatase Inhibitor										
Acien, P *et al.,* 2021, Spain.	Levonorgestrel / IUS	Randomized Clinical Trial	Radiological	Anastrozole 1 mg	15 vs 16	Yes		Yes		- Anastrazole and LNG-IUD reduce endometriosis-associated pain with a substantial difference (p = 0.048) in the first year of follow-up. - The recurrence rate between both groups was similar by the end of follow-up, but LNG-IUD tends to reoccur more rapidly than anastrozole.

TABLE 1. Summary and results of the included study. (Continue)

Author, Year, Country	Progestin Therapy	Type of Study	Type of Diagnosis	Comparator	Participants Included	Outcome Evaluated				Result
						Pain	QoL	Recurrence	Adverse Effects	
Progestin vs Placebo										
Tanmahasamut, P *et al.*, 2017. Thailand.	Desogestrel 0.075 mg / Oral	Randomized Clinical Trial	Surgical	Placebo	19 vs 19	Yes			Yes	- Desogestrel has significantly reduced the VAS score of pelvic pain, dysmenorrhea, and noncyclic pelvic pain (p = 0.005, p = 0.005, p = 0.007, respectively). However, there was no meaningful statistical difference in the VAS score of dyspareunia (p = 0.342). - The most frequent side effect of the treatment was menstrual alteration, which was consequently different in both groups (p < 0.001).
Lang, J *et al.*, 2017. China	Dienogest 2 mg / Oral	Randomized Clinical Trial	Surgical	Placebo	126 vs 129	Yes	Yes		Yes	- Dienogest has significantly reduced endometriosis-associated pelvic pain over placebo (p < 0.0001). - Diegonest has improved patients' quality of life. - The most frequent adverse effect was vaginal bleeding.
Yu, Q, *et. al.*, 2018. China	Dienogest 2 mg / Oral	Randomized Clinical Trial	Surgical	Placebo	109 vs 110	Yes	Yes		Yes	- Dienogest has significantly reduced endometriosis-associated pelvic pain over placebo (p < 0.0001). - Diegonest has improved patients' quality of life. - The most frequent adverse effect was vaginal bleeding.

Abbreviations: LNG-IUS = Levonorgestrel Intrauterine System, MPA Medroxyprogesterone Acetate, EE = Ethinyl Estradiol

and dyspareunia, which were not significantly different in both groups. The recurrence rate between both groups was not consequently different. Adverse effects were notably different between both groups, with the expected effects of DNG being headache in contrast to MPA, which was weight gain.[8]

Progestin, compared to other hormonal therapies Combined Oral Contraceptive (COC)

Kashi et al conducted a study comparing effects of dienogest, contraceptive oral contraceptive pills (COCP) containing ethinyl-estradiol (EE) and levonorgestrel and placebo. The results was a significant difference in the reduction of pelvic pain and dyspareunia between three groups but there was no significant difference between dysuria and dyschezia. Assessed QoL shows a notable difference in the mean score improvement with no statistical difference post-intervention between the three groups. There was a low adverse effect rate in the DNG and COCP groups. The most common side effects were spotting, hair loss, headache, hot flashes, and nausea, with unmeaningful difference in complications between the two groups.[9]

Caruso et al randomized women with endometriosis by confirming transvaginal sonography that received dienogest or COCP containing 17b-estradiol (E2) and nomegestrol acetate (NOMAC) to evaluate their effectiveness every 3 months within 12 months. It was reported that DNG had better improvements than E2/NOMAC, with unnoticeable differences. Both intervention groups had improvement in mental and somatic aspects with no statistical difference. However, DNG had a better somatic score than E2/NOMAC in 6 and 12 months, which is statistically meaningful.[10]

Another clinical trial performed by Niakan et al utilized comparison effects of dienogest, COCP containing EE/Levonorgestrel, and placebo within 12 weeks on

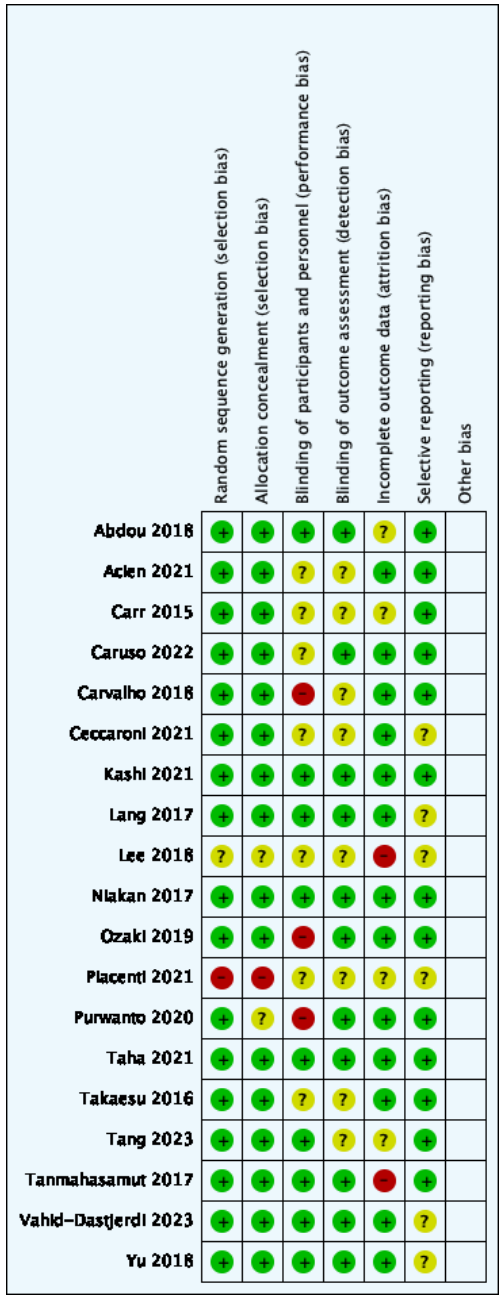


Fig 1. Risk of bias summary: Review authors' judgements about each risk of bias item for each included study.

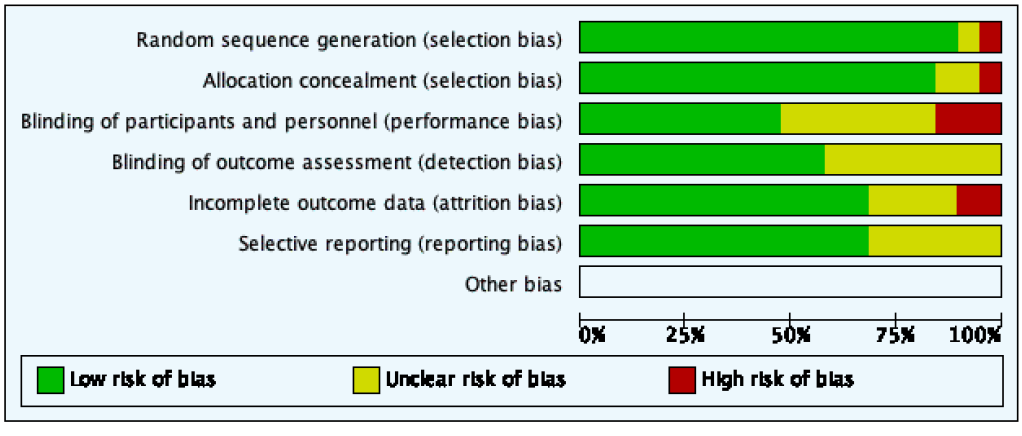


Fig 2. Risk of bias graph: Review authors' judgements about each risk of bias item presented as percentages across all included studies.

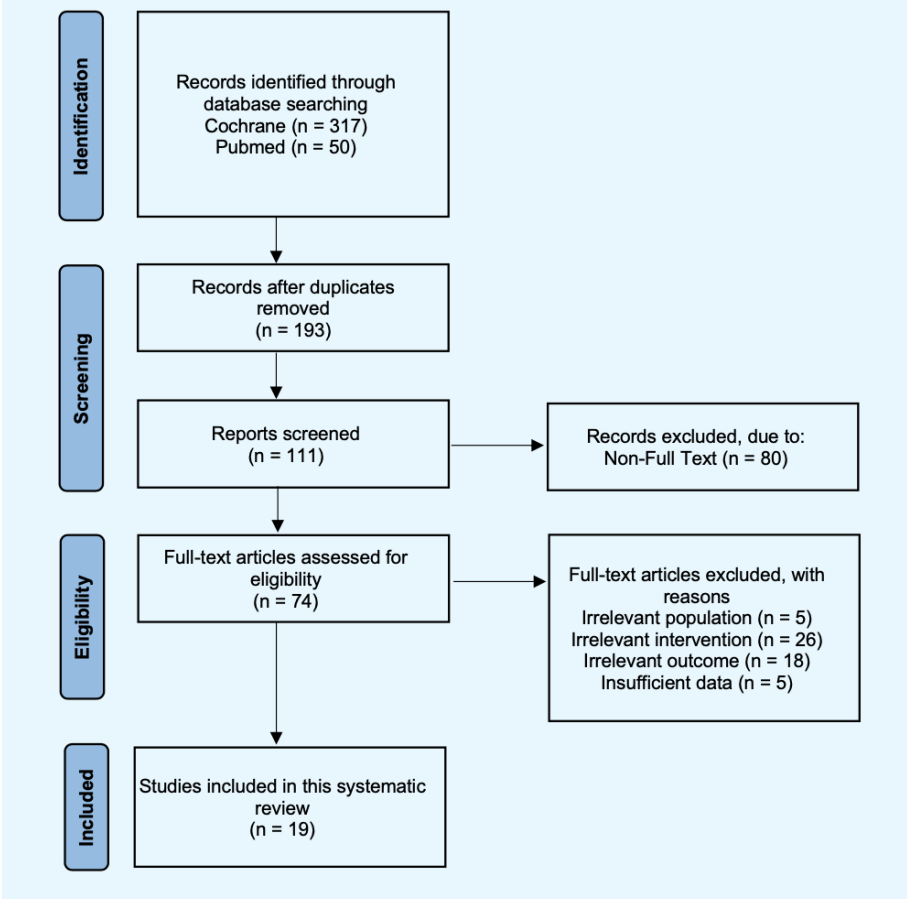


Fig 3. Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) criteria of the study.

women with surgical confirmed endometriosis. The mean VAS score of dyspareunia was reduced with no statistical difference between the three groups. Pelvic pain was reduced after 3 months post-intervention following dienogest, COCP and placebo. There is no significant effect of dienogest and COCP in treating dyschezia or dysuria. The mean overall score of QoL was substantially reduced in the three groups. Furthermore, the study discovered a low rate of adverse effects of dienogest and COCP, with the most common complications being hair loss, headache, hot flashes and nausea.[11]

Piacenti et al managed a study on surgical or radiological confirmed endometriosis with the therapy of oral dienogest or continuous EE/Levonorgestrel for 6 months. It was reported that dyspareunia and CPP significantly decreased, with no statistical difference between the two groups. QoL was improved, especially in the physical component, which decreased substantially, but there was no statistical difference between both groups. In addition, the study reported vaginal bleeding as the most frequent side effects.[12]

Taha et al. carried out a clinical trial comparing the efficacy of dienogest and COCP-containing EE/drospirenone. The study discovered that both interventions significantly improved the mean VAS score on non-cyclic pelvic pain; however, there are notable differences in statistics. Furthermore, CPP had a greater reduction of severity than dysmenorrhea and dyspareunia in both groups. The evaluation of QoL improvement was statistically meaningful, with no statistical differences in both interventions. The adverse effects encountered by patients were abnormal uterine bleeding, mood swings, headache, nausea and breast pain, which is more frequent in COCP than dienogest.[13]

Gonadotropin-releasing hormone agonist

After performing a surgical procedure to confirm endometriosis, Abdou et al. conducted a clinical trial comparing the effectiveness of dienogest consumed daily to leuprolide acetate (LA) injected monthly for 12 weeks. The alteration of the VAS score on pelvic pain, back pain and dyspareunia is significantly reduced, with no meaningful statistical difference between both interventions. The most frequent adverse effect in dienogest was vaginal bleeding and hot flushes, which were significantly higher than LA. Meanwhile, the most common adverse effect in LA is hot flushes and vaginal dryness, which were also consequently higher than the dienogest.[14]

Takaesu et al. conducted research on evaluating the efficacy of dienogest consumed daily and goserelin acetate injected monthly for 24 weeks and the group without any treatment assigned. Dysmenorrhea and CPP have significant improvement during progestin administration after 3 months of consumption, whereas it took 6 months for the non-treatment group. The study reported a gradual pain exacerbation in the three groups. The study only shows a substantial difference in recurrence rate between the dienogest and the non-treatment group. The most frequent side effect is irregular bleeding in the dienogest compared to goserelin, a hot flash.[15]

Purwanto et al. also performed a trial comparing the effect of therapy between dienogest and LA injected monthly within 12 weeks on women with laparoscopy-confirmed endometriosis. There was a decrease of VAS score in every 4 weeks of assessment in both groups with only a significant difference in the dienogest group. The side effects were found after 8 and 12 weeks of therapy. There are no statistical differences in adverse effects on both groups.[16]

Another research comparing the efficacy of dienogest and LA was conducted by Tang, Yang and Zhang on women with post-laparoscopic surgery in a 6-month observation. The average postoperative VAS score in both groups decreased; however, it only showed a statistically significant decrease in VAS score in the dienogest group. The recurrence incidence was eight patients in the dienogest with a 77.5% effectiveness rate and two patients in the LA group with an 82.9% effectiveness rate.[17]

Ceccaroni et al. compared two postoperative endometriosis treatments: oral dienogest and injection LA for 6 months for 30 months. It was found that both dienogest and GnRH agonists had noticeable reductions in dysmenorrhea, dyspareunia, dyschezia and CPP. The most frequent adverse effects of the dienogest were hot flushes in contrast to GnRH agonist, which was amenorrhea. Furthermore, there was a significantly lower incidence of amenorrhea and hot flushes in the GnRH agonist group than in the dienogest group. Meanwhile, there was a significantly higher incidence of spotting in the GnRH agonist group than in the dienogest group.18 Ozaki et al. carried out a clinical trial comparing the treatment outcome of post-laparoscopic endometriosis patients with daily oral dienogest and goserelin acetate injected monthly within 3 months. The comparison of preoperative and 4-month postoperative pain related to endometriosis was significantly lower in dienogest-administered patients than in goserelin acetate-injected patients. As for the adverse event, it showed that the incidence of hot flashes was lower in dienogest than in glycol acetate. In contrast, the incidence of breast pain and metrorrhagia was considerable higher statistically in goserelin acetate than dienogest.[19]

Gonadotropin-releasing hormone antagonist

Carr et al. conducted a randomized trial study comparing the outcome of depot medroxyprogesterone acetate (DMPA) administered subcutaneously on weeks 1 and 12 of treatment in contrast to oral GnRH agonist administered in two methods of dose (150 mg once daily and 75 mg twice daily). All treatment groups appeared to have a significant reduction of baseline VAS score in endometriosis-associated pain, with elagolix 75 mg twice a day having more pronounced effects compared to elagolix 150 mg every day and DMPA. The most frequent elagolix's side effects were headache, nausea, and nasopharyngitis, whereas DMPA were headache, nausea, and upper respiratory tract infection.[20]

Aromatase inhibitor

A clinical study performed by Acien et al. to determine the efficacy of a levonorgestrel-releasing intrauterine device (LNG-IUD) within 6 months and an aromatase inhibitor, which was anastrozole daily on patients with ultrasound-confirmed endometriosis. All endometriosis-related pain significantly improved in all groups during and after 6 months, and the most significant improvements observed were dysmenorrhea and CPP with anastrozole administered to the patient. Nevertheless, there was only a substantial difference between the anastrozole and non-anastrozole groups in the 1-year follow-up. The recurrence rate was similar between both groups (50%), but there was no consequential statistical difference.[21]

Placebo

A double-blinded, placebo-controlled, randomized study conducted by Tanmahasamut et al. assessed the efficacy of desogestrel daily in reducing endometriosis-associated pain for 6 months. Both groups significantly improved from the baseline VAS score in all types of pain. Desogestrel had a notable statistical difference in the VAS score reduction in overall pain, dysmenorrhea, and non-cyclic pelvic pain. Four patients were observed to have moderate-to-severe pain at 6 months post-treatment, which was significant statistically compared to desogestrel. Alteration of menstruation patterns was found in the desogestrel and the placebo, which was meaningful statistically.[22]

Another clinical placebo-controlled study was performed by Lang et al. to determine the effectiveness

of dienogest in endometriosis for 24 weeks. The study stated that the VAS score related to endometriosis-associated pelvic pain (EAPP) was an absolute reduction from the baseline, which was different considerably on the statistics after 24 weeks. Also, QoL shows improvement in the physical and mental health of dienogest. The most frequent adverse effect was vaginal haemorrhage.[23]

Yu et al. also conducted a placebo-controlled study to determine the efficacy of dienogest in endometriosis for 24 weeks. A mean change of VAS score from the baseline in EAPP on the dienogest group was found. On the contrary, the placebo group had a slight decrease in VAS scores. The study reported improvement in QoL in almost all physical and mental health domains. A slight decrease in mental health was observed in the placebo group, which may have affected the overall improvement. The most common adverse effect was vaginal haemorrhage.[24]

DISCUSSION

Interpretation of findings

Endometriosis is a hormone-dependent chronic inflammatory condition that needs prolonged therapy that corresponds to the efficacy of outcomes with sufficient tolerability. Hormonal therapies are necessary to be given to women with endometriosis by regulating hormones in order to prevent symptoms, progression of severity, and reoccurrence of the disease. Multiple aspects are considered when choosing the most convenient therapy, such as age, reproductive status, pain severity, economic status, possible adverse effects, incidence rate of recurrence, comorbidities, and many other considerations. Discontinuation of hormonal therapies tends to cause disease recurrence. The medication should be focused on long-term effectiveness with minimal adverse effects. Hormonal contraceptive therapies for endometriosis in this systematic review have significant outcomes in relieving endometriosis-associated pain, enhancing quality of life, preventing recurrence, and reducing the incidence of adverse effects.[2,4]

Among the proposed first-line therapies, progestogens have strong recommendations through their clinical effectiveness in treating endometriosis. In addition, progestogens have various modalities, availability, and affordable costs. Progestin is known for its indication of prolonged treatment. Dienogest is a fourth-generation high-selective progestogen, one of the first-line therapies for endometriosis. It is the first treatment choice due to its safety, efficacy, availability, tolerability, and affordable cost. The disadvantage of consuming dienogest might be the side effects, such as abnormal uterine bleeding; however, it has a lower side effect than other hormonal therapies in several studies.[25,26] Mostly, the studies included dienogest to be compared to other therapies and showed more efficacy than other hormonal treatments discussed below.

Throughout the study, progestogen showed significantly reduced endometriosis-related pain, lower recurrence incidence, minimal side effects, and improved quality of life of patients. Dienogest was compared to LNG-IUS, which both are effective. However, the comparison of efficacy was hardly known in contrast to being compared to oral medroxyprogesterone acetate, in which dienogest was more effective in relieving pain and had a lower incidence of adverse effects while the recurrence rate was similar.[6,8] LNG-IUS was also compared to another progestin-only contraceptives, an etonogestrel implant. Both were effective as long-term therapies, but both modalities have no significant difference in therapy outcomes. Therefore, LNG-IUS and etonogestrel implants are good choices for women who do not wish to consume medication daily. However, both modalities need to be administered by medical professionals due to their expensive cost and the possibility of unpredictable bleeding. Furthermore, those modalities may not overcome or control the pain.[7,25,27]

Three studies were conducted to determine the efficacy of progestogen: dienogest and desogestrel, which will be compared to placebo. Both dienogest and desogestrel were acceptable and effective as a treatment of endometriosis in reducing clinical symptoms, refining the quality of life and reducing the rate of side effects and recurrence.[22–24] Dienogest and desogestrel are selective progestins from nortestosterone derivatives which work specifically in endometrial tissues. Unlike other nortestosterone derivatives, dienogest has a lower androgenic effect with a higher anti-androgenic effect, which is beneficial in minimizing the effects of changes in fat and carbohydrate levels, while desogestrel has an androgenic effect. The selection of the type of progestin used must consider the androgenic effects, anti-mineralocorticoid effects, and glucocorticoid effects to minimise metabolic side effects.[28]

During the comparison between the progestogens and COC therapies, all of the progestogen treatments that were compared were only diengoest to various COCs. The most COC included in this study was oral ethinyl EE/levonorgestrel. It was an effective COC in treating endometriosis. However, dienogest had significantly reduced pain symptoms and higher quality of life scores than EE/levonorgestrel, but the incidence of side effects was similar in both interventions.[9,10,12] Other combinations of COC that were studied were the oral EE/ NOMAC

and EE / Drospirenone, which were also effective, but still, dienogest has a more significant impact in relieving symptoms, lower rate of side effects and better quality of patient life than both COC. COC is safe for long-term consumption, particularly for women who avoid unintended pregnancy.[10,13,29]

Another widely studied was the comparison between progestogens and GnRH agonists. Four studies used leuprolide acetate injection, which was compared to dienogest. Most of those studies mentioned that both hormonal interventions effectively treat endometriosis. However, dienogest has more advantages, such as it can be used as a long-term therapy with a lower recurrence rate and adverse effects than leuprolide acetate, which was only injected in short-term therapy.[14,16–18] Other two studies included goserelin acetate injection, which mentioned that dienogest was more effective than goserelin acetate in reducing endometriosis-associated pain. Regarding sustainability, dienogest is more sustainable than both GnRH agonist therapies.[15,19] Meanwhile, a study determined the efficacy of progestogens with GnRH antagonist and aromatase inhibitor, which can be prescribed as a second-line therapy for endometriosis. A clinical trial utilizing oral progestin-only contraceptives containing medroxyprogesterone acetate injected subcutaneously was compared to oral GnRH antagonist containing lanolin, mentioning that both hormonal interventions have a comparable efficacy on endometriosis therapy.[20] In addition, it is considered to combine hormone add-back therapy to avoid loss of bone mineral density in prescribing sole GnRH agonist and GnRH antagonists.[2,28]

This review also included one clinical trial using LNG-IUS compared to oral aromatase inhibitor anastrozole, which stated that prescribing both hormonal interventions was more effective than using LNG-IUS solely in reducing endometriosis-related symptoms. It is similar to guideline recommendations that aromatase inhibitors should be combined with other endometriosis hormonal therapies, such as progestogens, to reach their maximal efficacy.[21] In addition, long-term use of aromatase inhibitors can increase the risk of osteopenia, osteoporosis, and fracture; therefore, requires many considerations in prescribing aromatase inhibitors.[28]

Practical implications

Nowadays, the recent hormonal therapies include progestogen, combined oral contraceptive pills, aromatase GnRH agonists and antagonists in a variety of routes of administration. guidelines and expert insights have stated progestogen as an option in endometriosis.[30] Still, in choosing the suitable treatment options, it is recommended for clinicians to decide on an individual-based approach.[4] From all the proposed therapies, progestogen has appeared to be the foremost option utilized across nations. Progestogen that is prescribed by consideration of clinicians due to its side profile effects to each individual. Among the options of progestogen therapies, dienogest has emerged to be the most used progestogen.[4,30]

Dienogest, a 19-nortestosterone derivative, has been approved as an endometriosis treatment in several countries. Recently, there have been researches on investigating the safeness of dienogest to be a routine prescription on endometriosis in daily practices.[31] The Visanne Post-Approval Observation Study (VIPOS) is the largest non-interventional study conducted in six European countries in 7 years. The study mentioned that dienogest is safe as a long-term treatment for 15 months and longer with no serious side effects.[32] Meanwhile, The EffectiveNess of VISanne in Improving quality of life in Asian wOmen (ENVISIOeN), another non-interventional study carried out in six Asian countries concluded that dienogest improve patient's quality of life and endometriosis-associated pelvic pain in Asian women. The research also distinguished that dienogest can be a favorable first-line non-intervention option in a long-term treatment on alleviating endometriosis-related symptoms.[33]

Another treatment approach of endometriosis aside from hormonal therapies are non-hormonal therapies and surgery. The widely offered non-hormonal treatment on endometriosis is nonsteroidal anti-inflammatory drugs (NSAID). Although NSAID can be prescribed to patients on reducing endometriosis-associated pain solely or combined with hormonal therapy, it is incapable of reducing the progressivity of endometriosis. Also, several recent guidelines stated a weak recommendation on NSAID due to its gastrointestinal side effects especially in a long-term consumption.[4,34]

Surgery is as effective as hormonal therapy in relieving endometriosis associated-pain. Indication for surgery includes ovarian endometriomas, superficial peritoneal lesions, and deep infiltrating endometriosis that will decrease ovarian reserve by observing the measured anti-müllerian hormone (AMH) and ultrasonography measured total of the antral follicles.[35,36] In addition, undergoing surgery on endometriosis improves fertility outcomes by repairing the anatomical abnormalities caused by the ectopic endometrial implants.[37] Nowadays, one of the most common gynecological intervention, which is laparoscopy approach has been widely performed on endometriosis with its lower incidence of post surgery complications compared to laparatomy.[38,39] Aside from

its therapeutic function to endometriosis, laparoscopy approach also assists clinicians in diagnosing endometriosis along with MRI.[39,40] Hormonal therapy is suggested to be prescribed after the surgical intervention to enhance the outcome of the endometriosis-associated symptoms and prevent recurrence if the patient would not intend to get pregnant immediately. Meanwhile, in presurgical hormone treatment does not improve the surgery outcome but it is offered to reduce pain symptoms in a waiting interval as an adjunct before proceeding to surgical intervention.[4]

Limitations of study

The limitations of our systematic review are the limited number of studies carried out on each comparison of progestogens to other hormonal therapies due to our strict data inclusion requirement. The evidence of measured endometriosis-associated pain is diverse in every study included; therefore, it is challenging to compare. Furthermore, medication-related decrease in baseline parameters of pain is an important statement. However, it can be misleading to the placebo effect due to producing a high response rate, especially in a short-term study. A small-scale of populations might lead into a patient-based preference treatment and homogenous patients such as age, preference, socioeconomic status that can affect the interpretation of the investigations which also can be biased. Meanwhile, a brief follow-up research, could also influence the final interpretation mainly by only focusing on symptom improvement which might overshadow symptoms relapse, adverse effects and quality of life in the time ahead. A diverse and long-term follow-up could improve the conclusion more than previous.

Despite the various kinds of hormonal therapies that were compared, the distinct number of studies in every comparison of hormonal therapies made it challenging to assume the superiority of a specific, especially the lack of comparison of progestogen with progestogen itself, GnRH antagonist, and aromatase inhibitor. In addition, the progestogen that is compared to the placebo is only dienogest, which is now currently the most widely used progestogen in most countries. This made other progestogen effects to treat endometriosis unexplained well in comparison to placebo.

In terms of future research, identifying more studies in comparing progestin-only therapies to other hormonal therapies that might be used as endometriosis treatment with flexible criterias. By using more adjustable requirements of study such as a confined measured outcome could gain more studies than before that can be beneficial in concluding the findings. Furthermore, more investigations can be conducted regarding comparing progestins to other hormonal medications. It is also acceptable to any other aspect that could be analyzed to know the distinct superiority of hormonal contraception in endometriosis treatment, such as laboratory findings (hormone levels), radiological findings (endometrioma size), bone mineral density and others.

CONCLUSION

Based on the systematic review, progestogens are similarly effective or could be more effective than other hormonal treatments in decreasing endometriosis-associated pain, improving patients' life qualities, restraint relapse, and reducing adverse effects of endometriosis. There is no well-defined evidence of specific administration routes of progestogens that are more effective than another method of administration.

Data Availability Statement

This article review has provided all relevant publications.

ACKNOWLEDGEMENT

We would like to extend our sincere appreciation to all colleagues from Faculty of Medicine, Sriwijaya University for providing support and contributions.

DECLARATIONS

Grants and Funding Information

None.

Conflict of Interest

All authors acknowledge that there is no conflict of interest.

Registration Number of Clinical Trial

None.

Author Contributions

Conceptualization and methodology, S.A.P., R.N., and I.A.L. ; Investigation, S.A.P., R.N., I.A.L. ; Formal analysis, S.A.P., R.N., and I.A.L. ; Validation, R.N., I.A.L. ; Visualization and writing – original draft, S.A.P; Writing – review and editing, S.A.P. ; Supervision, R.N., I.A.L. ; All authors have read and agreed to the final version of the manuscript.

Use of Artificial Intelligence

There is no involvement of the artificial intelligence usage.

REFERENCES

1. Tsamantioti E, Mahdy H. Endometriosis. https://www.ncbi.nlm.nih.gov/books/NBK567777/.
2. Allaire C, Bedaiwy MA, Yong PJ. Diagnosis and management of endometriosis. CMAJ. 2023;195(10):E363-E71.
3. Chauhan S, More A, Chauhan V, Kathane A. Endometriosis: A Review of Clinical Diagnosis, Treatment, and Pathogenesis. Cureus. 2022;14(9):e28864.
4. Becker CM, Bokor A, Heikinheimo O, Horne A, Jansen F, Kiesel L, et al. ESHRE guideline: endometriosis. Hum Reprod Open. 2022;2022(2):hoac009.
5. Vannuccini S, Clemenza S, Rossi M, Petraglia F. Hormonal treatments for endometriosis: The endocrine background. Rev Endocr Metab Disord. 2022;23(3):333-55.
6. Lee KH, Jung YW, Song SY, Kang BH, Yang JB, Ko YB, et al. Comparison of the efficacy of diegnogest and levonorgestrel-releasing intrauterine system after laparoscopic surgery for endometriosis. J Obstet Gynaecol Res. 2018;44(9):1779-86.
7. Carvalho N, Margatho D, Cursino K, Benetti-Pinto CL, Bahamondes L. Control of endometriosis-associated pain with etonogestrel-releasing contraceptive implant and 52-mg levonorgestrel-releasing intrauterine system: randomized clinical trial. Fertil Steril. 2018;110(6):1129-36.
8. Vahid-Dastjerdi M, Hosseini R, Rodi H, Rastad H, Hosseini L. Comparison of the effectiveness of Dienogest with medroxyprogesterone acetate in the treatment of pelvic pain and recurrence of endometriosis after laparoscopic surgery. Arch Gynecol Obstet. 2023;308(1):149-55.
9. Mehdizadeh Kashi A, Niakan G, Ebrahimpour M, Allahqoli L, Hassanlouei B, Gitas G, et al. A randomized, double-blind, placebo-controlled pilot study of the comparative effects of dienogest and the combined oral contraceptive pill in women with endometriosis. Int J Gynecol Obstet. 2022;156(1):124-32.
10. Caruso S, Cianci A, Iraci Sareri M, Panella M, Caruso G, Cianci S. Randomized study on the effectiveness of nomegestrol acetate plus 17β-estradiol oral contraceptive versus dienogest oral pill in women with suspected endometriosis-associated chronic pelvic pain. BMC Womens Health. 2022;22(1):146.
11. Niakan G, Rokhgireh S, Ebrahimpour M, Kashi AM. Comparing the effect of dienogest and OCPS on pain and quality of life in women with endometriosis: A randomized, double-blind, placebo-controlled trial. Arch Iran Med. 2021;24(9):670-7.
12. Piacenti I, Viscardi MF, Masciullo L, Sangiuliano C, Scaramuzzino S, Piccioni MG, et al. Dienogest versus continuous oral levonorgestrel/EE in patients with endometriosis: what's the best choice? Gynecol Endocrinol. 2021;37(5):471-5.
13. El Taha L, Abu Musa A, Khalifeh D, Khalil A, Abbasi S, Nassif J. Efficacy of dienogest vs combined oral contraceptive on pain associated with endometriosis: Randomized clinical trial. Eur J Obstet Gynecol Reprod Biol. 2021;267:205-12.
14. Abdou AM, Ammar IMM, Alnemr AAA, Abdelrhman AA. Dienogest Versus Leuprolide Acetate for Recurrent Pelvic Pain Following Laparoscopic Treatment of Endometriosis. J Obstet Gynecol India. 2018;68(4):306-13.
15. Takaesu Y, Nishi H, Kojima J, Sasaki T, Nagamitsu Y, Kato R, et al. Dienogest compared with gonadotropin-releasing hormone agonist after conservative surgery for endometriosis. J Obstet Gynecol Res. 2016;42(9):1152-8.
16. Purwanto JP, Effendi Y, Manan H, Hoesin M. Effectiveness, Safety and Obedience of Dienogest and Leuprolide Acetate in Postlaparoscopic Endometriosis Patients. Indones J Obstet Gynecol. 2020;8(1):44-51.
17. Tang M, Yang W, Zhang H. Comparison of the efficacy of dienogest and GnRH-a after endometriosis surgery. BMC Womens Health. 2023;23(1):85.
18. Ceccaroni M, Clarizia R, Liverani S, Donati A, Ceccarello M, Manzone M, et al. Dienogest vs GnRH agonists as postoperative therapy after laparoscopic eradication of deep infiltrating endometriosis with bowel and parametrial surgery: a randomized controlled trial. Gynecol Endocrinol. 2021;37(10):930-3.
19. Ozaki R, Kumakiri J, Jinushi M, Ikuma S, Murakami K, Kawasaki Y, et al. Comparison of effect of preoperative dienogest and gonadotropin-releasing hormone agonist administration on laparoscopic cystectomy for ovarian endometriomas. Arch Gynecol Obstet. 2020;302(4):969-76.
20. Carr B, Dmowski WP, O'Brien C, Jiang P, Burke J, Jimenez R, et al. Elagolix, an oral GnRH antagonist, versus subcutaneous depot medroxyprogesterone acetate for the treatment of endometriosis: Effects on bone mineral density. Reprod Sci. 2014;21(11):1341-51.
21. Acién P, Velasco I, Acién M. Anastrozole and levonorgrestrel-releasing intrauterine device in the treatment of endometriosis: a randomized clinical trial. BMC Womens Health. 2021;21(1):211.
22. Tanmahasamut P, Saejong R, Rattanachaiyanont M, Angsuwathana S, Techatraisak K, Sanga-Areekul N. Postoperative desogestrel for pelvic endometriosis-related pain: a randomized controlled trial. Gynecol Endocrinol. 2017;33(7):534-9.
23. Lang J, Yu Q, Zhang S, Li H, Gude K, von Ludwig C, et al. Dienogest for Treatment of Endometriosis in Chinese Women: A Placebo-Controlled, Randomized, Double-Blind Phase 3 Study. J Womens Health. 2018;27(2):148-55.
24. Yu Q, Zhang S, Li H, Wang P, Zvolanek M, Ren X, et al. Dienogest for treatment of endometriosis in women: A 28-week, open-label, extension study. J Womens Health. 2019;28(2):170-7.
25. La Torre F, Vannuccini S, Toscano F, Gallucci E, Orlandi G, Manzi V, et al. Long-term treatment for endometriosis with dienogest: efficacy, side effects and tolerability. Gynecological Endocrinology. 2024;40(1):2336121.
26. Gokmen SB, Topbas Selcuki NF, Aydın A, Bahat PY, Akça A. Effects of Dienogest Therapy on Endometriosis-Related Dysmenorrhea, Dyspareunia, and Endometrioma Size. Cureus. 2023;15(1):e34162.
27. Gezer A, Oral E. Progestin therapy in endometriosis. Womens Health (Lond). 2015;11(5):643-52.
28. Pertama R. Konsesus Tata Laksana Nyeri Endometriosis. Himpunan Endokrinologi Reproduksi dan Fertilitas Indonesia (HIFERI). Perkumpulan Obstetri dan Ginekologi Indonesia (POGI), 2017.p.1.
29. da Costa Pinheiro DJP, Pereira AMG, Antonini M, Maria Albuquerque Salgado I, Dias AT, Lopes RGC. Tolerability of endometriosis medical treatment: a comparison between combined hormonal contraceptives and progestins. BMC Womens Health. 2023;23(1):510.
30. Lee J, Park HJ, Yi KW. Dienogest in endometriosis treatment: A narrative literature review. Clin Exp Reprod Med. 2023;50(4):223-9.
31. Crump J, Suker A, White L. Endometriosis: review of recent evidence and guideline. AJGP. 2024;53(1-2):11-8.
32. Moehner S, Becker K, Lange JA, von Stockum S, Serrani M,

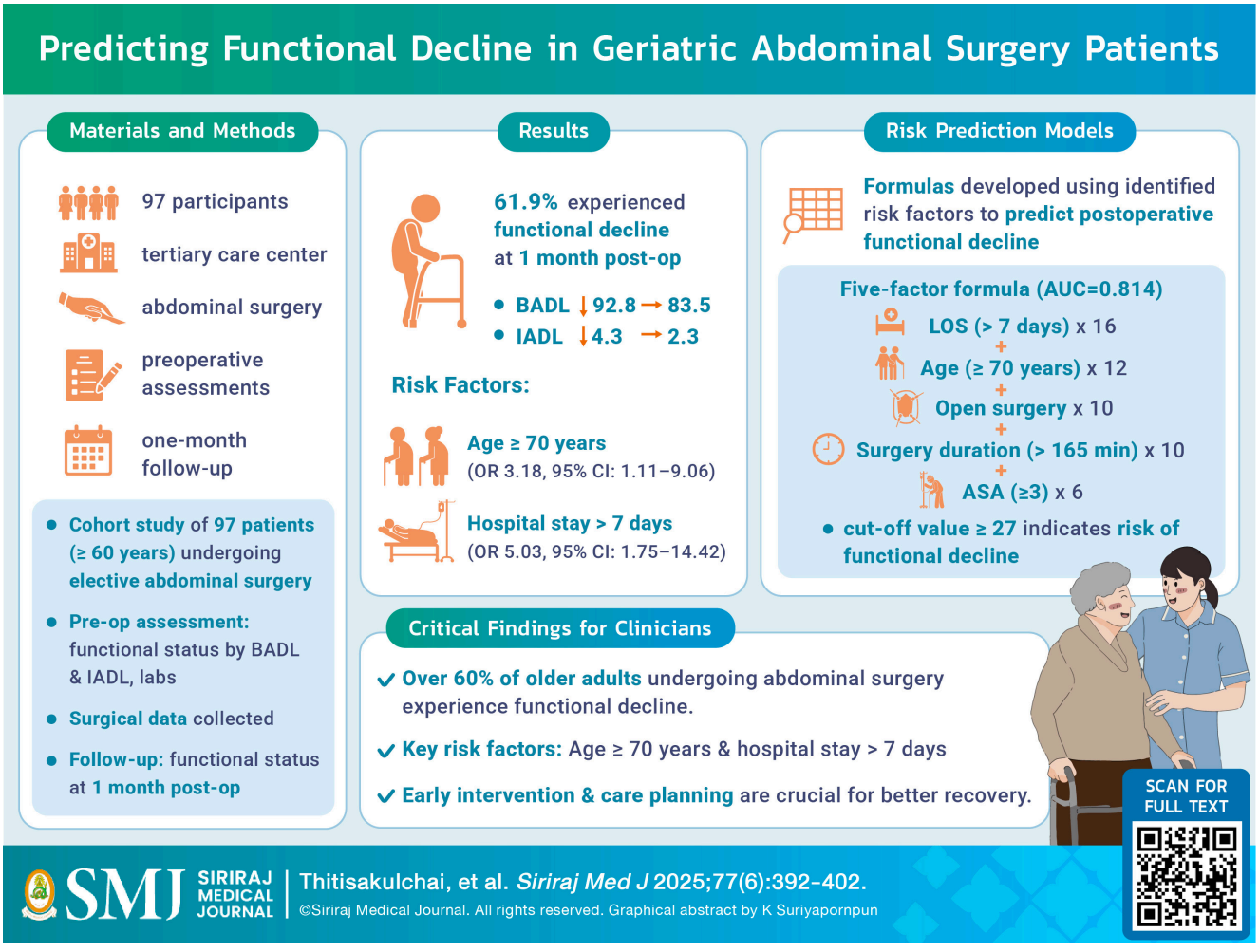
Heinemann K. Long-term treatment of endometriosis with dienogest: Real-world results from the VIPOS study. J Endometr Pelvic Pain Disord. 2021;13(2):104-10.

33. Techatraisak K, Hestiantoro A, Soon R, Banal-Silao MJ, Kim M-R, Seong SJ, et al. Impact of Long-Term Dienogest Therapy on Quality of Life in Asian Women with Endometriosis: the Prospective Non-Interventional Study ENVISIOeN. Reprod Sci. 2022;29(4):1157-69.
34. Kalaitzopoulos DR, Samartzis N, Kolovos GN, Mareti E, Samartzis EP, Eberhard M, et al. Treatment of endometriosis: a review with comparison of 8 guidelines. BMC Womens Health. 2021;21(1):397.
35. Saridogan E, Becker CM, Feki A, Grimbizis GF, Hummelshoj L, Keckstein J, et al. Recommendations for the Surgical Treatment of Endometriosis. Part 1: Ovarian Endometrioma. Hum Reprod Open. 2017;2017(4):hox016.
36. Keukens A, Veth VB, Regis M, Mijatovic V, Bongers MY, Coppus SFPJ, et al. The effect of surgery or medication on pain and quality of life in women with endometrioma. A systematic review and meta-analysis. Eur J Obstet Gynecol Reprod Biol. 2024;293:95-105.
37. Ratan A, Pradhan S, Panigrahi PK, Sahu M, Peepal P, Das S. Role of Laparoscopy in Diagnosis and Treatment of Endometriosis Associated with Infertility: A Prospective Analysis. Siriraj Med J [internet]. 2021 Nov. 1 [cited 2025 Jan. 18];73(11):772-6. Available from: https://he02.tci-thaijo.org/index.php/sirirajmedj/article/view/254174
38. Srichaikul P, Chalermchockcharoenkit A, Yahata H, Sirimai K, Sutchritpongsa P. Low Complication Rate Associated with Total Laparoscopic Hysterectomies Using the Retroperitoneal Approach: A Series of 1,092 Cases in Siriraj Hospital. Siriraj Med J [internet]. 2018 Jun. 20 [cited 2025 Jan. 18];70(3):191-7. Available from: https://he02.tci-thaijo.org/index.php/sirirajmedj/article/view/129605
39. Chalermchockcharoenkit A, Techatraisak K. Diagnostic Laparoscopy and Endometriosis. Siriraj Med J [internet]. 2020 Aug. 11 [cited 2025 Jan. 18];53(3):145-51. Available from: https://he02.tci-thaijo.org/index.php/sirirajmedj/article/view/244096
40. Sutchritpongsa P, Schweppe K-W, Oehmke F, Tinneberg H-R. Accuracy of Magnetic Resonance Imaging in Diagnosis of Adenomyosis and Endometriosis. Siriraj Med J [internet]. 2008 Nov. 1 [cited 2025 Jan. 18];60(6):320-3. Available from: https://he02.tci-thaijo.org/index.php/sirirajmedj/article/view/246499

Predicting Functional Decline in Geriatric Abdominal Surgery Patients: Unveiling Incidence, Risk Factors, and Innovative Predictive Models in Thailand

Poungkaew Thitisakulchai, M.D.[1], Arunotai Siriussawakul, M.D.[2,3], Sunit Jarungjitaree, M.Sc.[3], Nipaporn Sangarunakul, B.NS.[3], Piyapat Dajpratham, M.D.[1,*]

[1]Department of Rehabilitation Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand, [2]Department of Anesthesiology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand, [3]Integrated Perioperative Geriatric Excellent Research Center, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand.



*Corresponding author: Piyapat Dajpratham
E-mail: piyapat.daj@mahidol.ac.th
Received 18 November 2024 Revised 21 January 2025 Accepted 22 January 2025
ORCID ID:http://orcid.org/0000-0002-6067-0319
https://doi.org/10.33192/smj.v77i6.272262

ABSTRACT

Objective: Surgery poses significant challenges for older adults, potentially leading to functional decline. This study investigated the incidence and risk factors associated with postoperative functional decline in older adults and developed formulas to predict its occurrence.

Materials and Methods: This cohort study analyzed patients aged 60 and over who underwent elective abdominal surgery at a tertiary care center in Thailand. The baseline characteristics including Basic Activities of Daily Living [BADL] and Instrumental Activities of Daily Living [IADL] scores, preoperative laboratory testing and surgery-related data were recorded. Functional status was reassessed one month post-surgery.

Results: The study involved 97 participants. One month post-surgery, the incidence of functional decline was 61.9%. The mean BADL and IADL scores in the functional decline group decreased from 92.8 ± 11.3 to 83.5 ± 17.8 and from 4.3 ± 1.3 to 2.3 ± 1.3, respectively ($p<0.001$). Multivariable logistic regression analysis identified age ≥ 70 years (adjusted OR 3.18, 95% CI 1.11–9.06, $p=0.031$) and a length of stay > 7 days (adjusted OR 5.03, 95% CI 1.75–14.42, $p=0.003$) as factors most strongly associated with functional decline. Formulas created using five factors related to decline from univariable analyses effectively predicted its occurrence, with AUCs ranging from 0.766 to 0.814.

Conclusion: Over 60% of older adults who underwent abdominal surgery experienced functional decline one month after surgery. The developed formulas can be used to identify patients at risk and help prevent functional decline in this population.

Keywords: Activities of daily living; functional status; geriatrics; risk factors; surgery (Siriraj Med J 2025; 77: 392-402)

INTRODUCTION

The aging of the global population has become a growing concern in recent years. One of the most prevalent issues among older adults is functional decline,[1] which is characterized by a decreased ability to perform activities of daily living. This condition poses significant challenges, adversely impacting their independence, social interactions, overall life satisfaction, and quality of life.[2]

In addition, older individuals often battle diverse illnesses, including some that may require surgical intervention. For those in advanced age, undergoing major surgery represents a critical event that can expose them to various complications. It can result in both short-term and sustained functional decline, which can shorten their survival, increase healthcare utilization, or even lead to institutionalization after surgery.[3-5]

Several studies have sought to identify risk factors associated with postoperative functional decline and poorer surgical outcomes in older individuals across various circumstances.[4–14] Researchers have also attempted to predict this decline using predictive indices that encompass a range of parameters and screening tools with varying degrees of accuracy.[15-18] However, for elective abdominal surgery, which accounts for approximately 40% of all surgical procedures performed on older patients in our institution, the frequency and determinants of postoperative functional decline remain unclear. Furthermore, a simple and effective method to predict and identify at-risk individuals has yet to be established.

Against this background, our research aims to identify the incidence rate and risk factors of functional decline following elective abdominal surgery in older adults. Additionally, we aim to utilize these factors to formulate simple equations that predict its occurrence. We believe these findings will offer valuable insights into patient care by aiding in the identification of individuals at risk, enabling healthcare providers to implement appropriate interventions, and potentially improving patient outcomes and recovery trajectories.

MATERIALS AND METHODS

Study design

This prospective cohort study was conducted at a tertiary care center in Thailand between August 2019 and March 2021. Corresponding to the statutory retirement age in Thailand, the inclusion criteria comprised individuals aged 60 years and older who were undergoing elective abdominal surgery. The exclusion criteria included patients scheduled solely for gastrostomy or jejunostomy, as well as those already in a state of dependence (Barthel Index < 10).

Measurements

The ASA Physical status serves as a classification system for assessing the preoperative health status of

individuals. The scale comprises five classes, ranging from ASA 1 to ASA 5. Notably, an ASA status of 3 or higher is reported to be related to poorer postoperative outcomes.[13-15]

Physical condition was assessed using the Medical Research Council sum score and a 30-second chair stand test. The sum score comprises the combined scores from 6 muscle groups in the upper and lower extremities on both sides.[19] The score ranges from 0 to 60, and is typically used to evaluate global peripheral muscle strength. The 30-second chair stand test involves recording the total number of completed chair stands executed in 30 seconds. The test assesses lower body strength and endurance in older adults.[20]

Functional status was measured by evaluating Basic Activities of Daily Living (BADLs) and Instrumental Activities of Daily Living (IADLs) using the Barthel Index and the Lawton IADL scale, respectively. The Barthel Index evaluates a patient's functionality across 10 BADL items (feeding, grooming, transfer, toilet use, mobility, dressing, stairs, bathing, and bowel and bladder control) with a final score ranging from 0 to 100,while the Lawton IADL scale was used to assess 5 IADL items (ability to use telephone, shopping, transportation, managing medications, and managing finances), with an overall score ranging from 0 to 5. [21,22,23] For both indices, scores are assigned based on the ability to perform each task independently, and lower scores indicate a higher level of dependency.

Cognitive function was evaluated using the Thai Mental State Examination (TMSE). With the maximum score of 30, a higher score represents better cognitive function. A cutoff score of < 24 is used to signify the presence of cognitive impairment.[24]

Nutritional status was evaluated by the Mini Nutritional Assessment short-form (MNA-SF), a validated tool designed to assess nutritional status in older adults. The score can range from 0 to 14, with higher scores indicating better nutrition. Patients with a score of 7 or lower were considered malnourished.[25]

Depression was evaluated through the Patient Health Questionnaire-9 (PHQ-9), which comprises 9 items assessing the frequency of depressive symptoms experienced by patients. Each item is scored on a scale from 0 to 3, resulting in an overall score ranging from 0 to 27. A cutoff score of ≥ 9 is applied to identify the presence of depression.[26]

Quality of life was assessed using the EQ-5D-5L questionnaire, which covers 5 dimensions with 5 items each. Responses were converted into an index value, known as the utility score, utilizing standard values specific to Thailand. The maximum utility score is 1, with a higher value indicating a better health state. Additionally, participants were asked to rate their self-perceived current health status using the EQ Visual Analogue Scale (EQ-VAS), which ranges from 0 (worst) to 100 (best health).

Data collection

Before surgery, a research assistant, uninvolved in any therapeutic procedures, collected data on patient demographics, physical condition, functional status, cognitive function, depressive symptoms, nutritional status, and quality of life. Preoperative laboratory tests were conducted to measure hemoglobin, albumin, and vitamin D levels. After discharge, another research assistant retrospectively reviewed medical records to collect perioperative details, including the type of surgery (upper abdominal, lower abdominal, or urological), surgical technique (open or laparoscopic), surgery duration, estimated blood loss (EBL), and length of stay (LOS). Postoperative complications, such as infectious, surgical, cardiovascular, respiratory, renal, and neurological issues, were documented according to established criteria from previous studies.[13,27] One month after surgery, the initial research assistant conducted a telephone follow-up to reassess each patient's functional status, depressive symptoms, and quality of life. Of all participants, only one remained hospitalized and was reassessed directly in the ward. The participants were then divided into 2 groups (functionally stable and functionally declined) based on changes in their functional capacity between baseline and follow-up. In line with a preceding study, functional decline was defined as a decrease of ≥ 10 points in BADLs on the Barthel Index or ≥ 2 points in IADLs on the Lawton IADL scale between the 2 assessments.[12]

Statistical analyses

Continuous variables with normal distributions are presented as means ± standard deviations, while non-normally distributed variables are shown as medians (IQR). Categorical data are expressed as numbers and percentages. As cut-off points for continuous variables, such as LOS, EBL, and surgery duration, are typically determined based on clinical context or operation category, we employed Receiver Operating Characteristic (ROC) analyses to define optimal thresholds. These cut-off values were selected to achieve the best balance between sensitivity and specificity, as determined by the Youden index.[28] The corresponding area under the ROC curve (AUC) values for the selected thresholds are as follows: LOS > 7 days (0.725), EBL > 550 ml (0.586), and surgery

duration > 165 minutes (0.598). Associations between variables and outcomes in the univariable analysis were assessed using independent t-tests, chi-square tests, or Mann–Whitney U tests, as appropriate. Comparisons of BADLs and IADLs within groups were analyzed using paired t-tests, while comparisons between groups were analyzed using independent t-tests. A p-value of less than 0.05 was considered significant for all analyses. Factors showing statistical significance in the univariable analysis were introduced into a multivariable logistic regression model to control for potential confounding factors. These significant factors were also used to formulate predictive equations for postoperative functional decline. Model discrimination was assessed by the AUC of each equation. All analyses were conducted using PASW Statistics for Windows, version 18.0 (SPSS Inc, Chicago, IL, USA).

RESULTS

A total of 190 patients scheduled for elective abdominal surgery and meeting the inclusion criteria were approached. Of these, 100 provided informed consent to participate in the study. However, 2 were not operated on due to unstable medical conditions, and 1 died after surgery. Consequently, these 3 were excluded from the final study cohort (Fig 1). The remaining 97 participants had a mean age of 70.2 ± 6.6 years, with 64.9% being male. 37.1% had an ASA classification of 3, while the rest had a classification of 2. The mean TMSE score was 25.1 ± 3.9, while the mean BADL and IADL scores were 92.8 ± 11.1 and 4.1 ± 1.5, respectively. The mean MNA-SF score, blood albumin, and vitamin D levels were within normal ranges and no statistical significance was observed between the groups (Table 1).

Regarding the operation, 71.1% were open surgeries, while 28.9% were performed laparoscopically. 69.1% of the surgical procedures exceeded a duration of 165 minutes. The median LOS was 7 days (IQR 5–10), with 44.3% of participants staying more than 7 days (Table 2). Nearly one-third of participants (28.9%) had 1 or more postoperative complications during admission. The most common complications were infectious, surgical, cardiovascular, renal, neurological, and respiratory (10.3%, 7.2%, 6.2%, 6.2%, 5.2%, and 4.1%) respectively.

At the one month follow-up, the incidence of functional decline, as defined previously, was 61.9%. Within the decline group, 31.7% showed a decrease in BADLs only, 46.7% in IADLs only, and 21.7% in both BADLs and IADLs. The BADL items significantly impacted were mobility, stair climbing, bathing, toilet use, and bladder control, while all aspects of IADL except telephone usage were affected. No statistically significant improvement in EQ-5D-5L utility score was observed for both the functionally stable and the functionally declining group. However, the stable group reported a significantly higher EQ-VAS (self-perceived health) score post operation than the declining group (77.6 ± 12.3 vs.

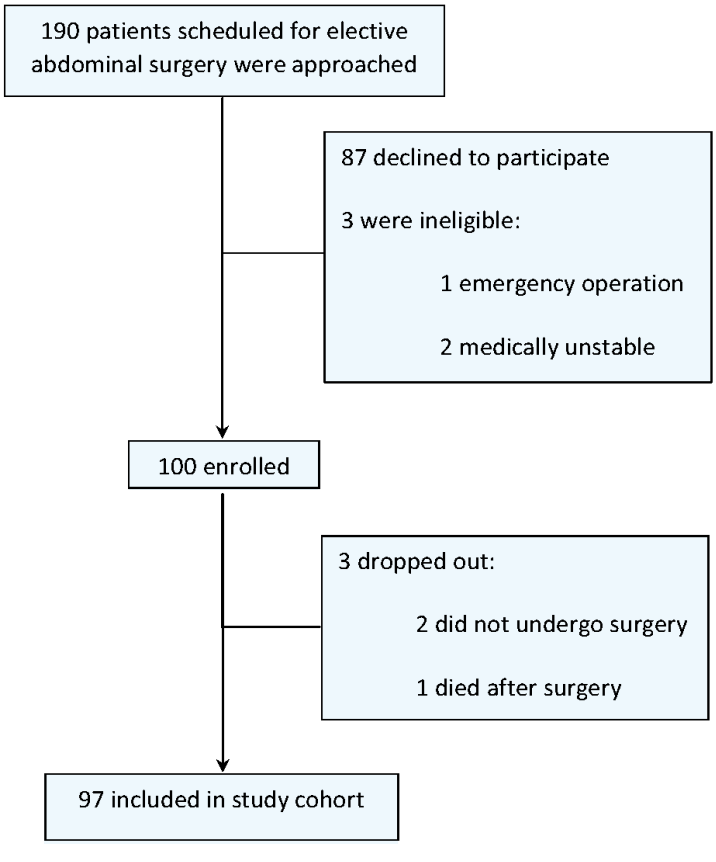


Fig 1. Flow diagram of the study.

TABLE 1. Baseline characteristics of patients and preoperative laboratory findings.

Variables	Total n = 97	Stable n = 37	Functional decline n = 60	p-value
Age (years), M (SD)	70.2 (6.6)	69.0 (6.6)	70.9 (6.6)	0.175
60–69, n (%)	51 (52.6)	26 (70.3)	25 (41.7)	0.006*
≥ 70, n (%)	46 (47.4)	11 (29.7)	35 (58.3)	
Sex, n (%)				
Male	63 (64.9)	25 (67.6)	38 (63.3)	0.671
Female	34 (35.1)	12 (32.4)	22 (36.7)	
BMI (kg/m^2), M (SD)	23.7 (3.8)	24.0 (3.9)	23.6 (3.8)	0.601
Education, n (%)				
≤ 12 years	71 (73.2)	28 (75.7)	43 (71.7)	0.665
> 12 years	26 (26.8)	9 (24.3)	17 (28.3)	
Comorbidities, n (%)				
Diabetes mellitus	29 (29.9)	10 (27.0)	19 (31.7)	0.628
Hypertension	64 (66.0)	21 (56.8)	43 (71.7)	0.132
Dyslipidemia	35 (36.1)	11 (29.7)	24 (40.0)	0.306
Chronic kidney disease	3 (3.1)	0 (0)	3 (5.0)	0.285
Musculoskeletal problems	36 (37.1)	10 (27.0)	26 (43.3)	0.106
ASA physical status, n (%)				
ASA 3	36 (37.1)	9 (24.3)	27 (45.0)	0.041*
ASA 2	61 (62.9)	28 (75.7)	33 (55.0)	
Ambulatory status, n (%)				
Walking	94 (96.9)	35 (94.6)	59 (98.3)	0.556
Chair-bound	3 (3.1)	2 (5.4)	1 (1.7)	
Walking assistance, n (%)				
With gait aid	11 (11.3)	4 (10.8)	7 (11.7)	1.00
Without gait aid	86 (88.7)	33 (89.2)	53 (88.3)	
BADL score, M (SD)	92.8 (11.1)	93.0 (10.8)	92.8 (11.3)	0.924
IADL score, M (SD)	4.1 (1.5)	3.7 (1.7)	4.3 (1.3)	0.084
Hemoglobin (g/dl), M (SD)	11.9 (2.1)	12.2 (2.1)	11.6 (2.0)	0.167
Albumin (g/dl), M (SD)	4.0 (0.5)	3.9 (0.4)	4.0 (0.6)	0.812
Vitamin D (ng/ml), M (SD)	25.4 (9.2)	25.8 (8.7)	25.2 (9.6)	0.727
MRC sum score, M (SD)	58.4 (3.3)	58.1 (3.7)	58.5 (3.1)	0.538
30 sec chair stand (times), M (SD)	10.9 (4.1)	11.2 (4.4)	10.7 (4.0)	0.575
MNA-SF score, M (SD)	11.0 (2.7)	11.0 (2.5)	10.9 (2.8)	0.846
TMSE score, M (SD)	25.1 (3.9)	25.1 (4.4)	25.1 (3.6)	0.949

Continuous data were analyzed using independent t-tests, and categorical data were analyzed using chi-square tests.

* Significant at p-value < 0.05

Abbreviations: ASA, American Society of Anesthesiologists; BADL, Basic Activities of Daily Living; BMI, Body Mass Index; IADL, Instrumental Activities of Daily Living; M, mean; MNA-SF, Mini Nutritional Assessment short-form; MRC, Medical Research Council; SD, standard deviation; TMSE, Thai Mental State Examination

TABLE 2. Surgery-related variables

Variables	Total n = 97	Stable n = 37	Functional decline n = 60	p-value
Type of surgery, n (%)				
Upper abdominal	33 (34.0)	16 (43.2)	17 (28.3)	0.132
Lower abdominal	29 (29.9)	12 (32.4)	17 (28.3)	0.668
Urological procedures	35 (36.1)	9 (24.3)	26 (43.3)	0.058
Method of surgery, n (%)				
Open surgery	69 (71.1)	21 (56.8)	48 (80.0)	0.014*
Laparoscopic surgery	28 (28.9)	16 (43.2)	12 (20.0)	
Surgery duration, median (IQR)	205 (155,285)	185 (150,260)	207.5 (170,322.5)	0.106
> 165 minutes, n (%)	67 (69.1)	21 (56.8)	46 (76.7)	0.039*
EBL, median (IQR)	150 (400,1100)	300 (100,700)	490 (150,1280)	0.158
> 550 ml, n (%)	37 (38.1)	10 (27.0)	27 (45.0)	0.077
≥ 1 complication, n (%)	28 (28.9)	7 (18.9)	21 (35.0)	0.090
LOS (days), median (IQR)	7 (5,10)	6 (4,7)	8 (6,12.5)	< 0.001*
> 7 days, n (%)	43 (44.3)	7 (18.9)	36 (60.0)	< 0.001*

Categorical data were analyzed using chi-square tests. Non-normally distributed data are presented as median (IQR) and analyzed using Mann–Whitney U tests.

* Significant at p-value < 0.05

Abbreviations: IQR, interquartile range; LOS, length of stay; EBL, estimated blood loss; ml, milliliter; M, mean; SD, standard deviation

72.8 ± 14.9, p=0.023). The stable group also presented a lower postoperative PHQ-9 score (fewer depressive symptoms) than the declining group (2.8 ± 3.2 vs. 3.9 ± 3.7, p=0.051; Table 3).

Factors found to be associated with functional decline from the univariable analysis were age ≥ 70, ASA ≥ 3, open surgery technique, surgery duration > 165 minutes, and LOS > 7 days. After a multivariable analysis adjusting for other variables in the model, the factors significantly associated with postoperative functional decline were age ≥ 70 (adjusted odds ratio [OR] 3.18, 95% confidence interval [CI] 1.11–9.06) and LOS > 7 days (adjusted OR 5.04, 95% CI 1.75–14.42; Table 4). Other variables, including laboratory testing, physical condition, and nutritional status, showed no significant association with functional changes after surgery.

The five factors showing statistical significance from the univariable analysis were used to develop four predictive equations. These equations incorporated either two, three, four, or all five factors in order of their significance. To predict the risk of functional decline, each factor present in a patient was assigned a value of 1, and its absence a value of 0. This value was then multiplied by a coefficient derived from the β coefficient of each factor, representing its association with decline. If the resulting value from each equation met or exceeded the cut-off, it indicated a risk of postoperative functional decline. The predictive accuracy increased with the number of factors used, yielding AUCs of 0.766, 0.788, 0.805, and 0.814 for the two-, three-, four-, and five-factor formulas, respectively. The five-factor formula showed the best performance, with an accuracy of 74.2%, a positive predictive value of 83.0%, a negative predictive value of 63.6%, a sensitivity of 73.3%, and a specificity of 75.7% (p<0.001) (Table 5).

DISCUSSION

This study examined the incidence rate and risk factors associated with postoperative functional decline following elective abdominal surgery in older patients. Our findings revealed that nearly two-thirds of the patients experienced a decline in function one month after surgery. Age ≥ 70 and LOS > 7 days were identified as the factors

TABLE 3. Comparison of pre- and postoperative outcome scores.

Variables	Stable n = 37			Functional decline n = 60			
	Preop	Postop	Post–Pre	Preop	Postop	Post–Pre	p-value
BADL score, M (SD)	93.0 (10.8)	94.5 (10.7)	1.5 (3.5)	92.8 (11.3)	83.5 (17.8)	-9.3 (11.6)	< 0.001*
Feeding	10.0 (0)	10.0 (0)	0	9.8 (0.9)	9.6 (1.7)	-0.3 (1.7)	0.260
Transfer	14.2 (2.8)	14.3 (2.7)	0.1 (0.8)	14.8 (0.9)	14.6 (1.7)	-0.3 (1.7)	0.202
Grooming	5.0 (0)	5.0 (0)	0	4.9 (0.6)	4.8 (0.9)	-0.1 (0.6)	0.435
Toilet use	9.9 (0.8)	9.7 (1.6)	-0.1 (0.8)	9.8 (0.9)	8.9 (2.8)	-0.9 (2.3)	0.021*
Bathing	4.7 (1.1)	4.7 (1.1)	0	4.8 (1.1)	4.1 (2.0)	-0.7 (1.9)	0.010*
Mobility	14.1 (2.8)	14.3 (2.7)	0.3 (1.1)	14.5 (2.0)	13.5 (3.9)	-1.0 (3.0)	0.004*
Stairs	9.1 (2.8)	9.3 (2.4)	0.3 (1.1)	9.4 (2.3)	6.6 (4.7)	-2.8 (4.6)	< 0.001*
Dressing	9.9 (0.8)	9.9 (0.8)	0	9.8 (1.1)	9.5 (1.5)	-0.3 (1.1)	0.083
Bowels	8.8 (3.0)	8.5 (3.3)	-0.3 (2.0)	7.5 (4.0)	7.1 (4.3)	-0.4 (3.5)	0.817
Bladder	7.4 (4.2)	8.7 (3.0)	1.2 (3.2)	7.3 (4.0)	4.8 (4.9)	-2.5 (4.5)	< 0.001*
IADL score, M (SD)	3.7 (1.7)	3.6 (1.8)	-0.1 (0.7)	4.3 (1.3)	2.3 (1.3)	-1.9 (1.3)	< 0.001*
Telephone	0.9 (0.3)	0.9 (0.3)	0 (0.2)	1.0 (0.2)	0.9 (0.3)	-0.1 (0.3)	0.266
Shopping	0.6 (0.5)	0.6 (0.5)	0 (0.4)	0.9 (0.4)	0.2 (0.4)	-0.7 (0.5)	< 0.001*
Transportation	0.7 (0.5)	0.6 (0.5)	-0.1 (0.3)	0.7 (0.5)	0.3 (0.5)	-0.4 (0.5)	0.001*
Managing medications	0.8 (0.4)	0.8 (0.4)	0 (0.4)	0.9 (0.3)	0.8 (0.4)	-0.2 (0.4)	0.015*
Managing finances	0.7 (0.5)	0.7 (0.5)	-0.1 (0.4)	0.8 (0.4)	0.2 (0.4)	-0.6 (0.5)	< 0.001*
EQ-5D-5L, M (SD)	0.87 (0.17)	0.93 (0.15)	0.05 (0.20)	0.87 (0.14)	0.87 (0.19)	0 (0.20)	0.209
EQ-VAS, M (SD)	68.5 (16.2)	77.6 (12.3)	9.1 (16.1)	72.5 (16.3)	72.8 (14.9)	0.3 (19.2)	0.023*
PHQ-9, M (SD)	4.0 (4.2)	2.8 (3.2)	-1.2 (3.9)	3.3 (3.1)	3.9 (3.7)	0.6 (4.3)	0.051

* Significant at p-value < 0.05

Abbreviations: BADL, Basic Activities of Daily Living; IADL, Instrumental Activities of Daily Living; M, mean; PHQ-9, Patient Health Questionnaire-9; SD, standard deviation

most closely associated with the decline, while other factors, such as ASA ≥ 3, surgery duration > 165 minutes, and the use of open surgery techniques, showed a lower level of association. These findings emphasize the need for evaluations that address not only surgical risk but also strategies to mitigate postoperative functional decline, while highlighting the importance of incorporating geriatric considerations into surgical care to optimize patient-centered outcomes. By combining these factors, we developed a predictive model that integrates commonly available clinical variables to estimate the likelihood of functional decline following surgery. This approach underscores the potential for individualized patient management and proactive planning, ultimately aiming to reduce the burden of postoperative morbidity in older populations.

TABLE 4. Results of multivariable logistic regression analysis to determine predictive factors for postoperative functional decline.

Variables	β coefficients	Crude odds ratio (95% CI)	p-value	Adjusted odds ratio (95% CI)	p-value
Age ≥ 70 years	1.155	3.30 (1.38–7.91)	0.006	3.18 (1.11–9.06)	0.031*
ASA ≥ 3	0.621	2.55 (1.03–6.31)	0.041	1.86 (0.62–5.59)	0.268
Open surgery	1.088	3.05 (1.23–7.55)	0.014	2.97 (0.98–8.99)	0.054
Surgery duration > 165 min	0.982	2.50 (1.04-6.06)	0.039	2.67 (0.93-7.68)	0.069
LOS > 7 days	1.614	6.43 (2.43-16.98)	< 0.001	5.03 (1.75–14.42)	0.003*

* Significant at p-value < 0.05

Abbreviations: ASA, American Society of Anesthesiologists; LOS, length of stay. Each variable was adjusted for other variables included in the model.

TABLE 5. Receiver operating characteristics of the predictive formulas.

Formula characteristics	Two-factor formula	Three-factor formula	Four-factor formula	Five-factor formula
AUC	0.766	0.788	0.805	0.814
p-value	<0.001	<0.001	<0.001	<0.001
Accuracy (95%CI)	74.2% (64.3-82.6)	75.3% (65.5-83.5)	73.2% (63.2-81.7)	74.2% (64.3-82.6)
PPV (95%CI)	76.9% (68.9-83.3)	82.1% (72.7-88.8)	85.4% (74.6-92.1)	83.0% (73.1-89.8)
NPV (95%CI)	68.8% (54.1-80.4)	65.9% (53.9-76.1)	61.2% (51.3-70.3)	63.6% (52.5-73.4)
Sensitivity (95%CI)	83.3% (71.5-91.7)	76.7% (64.0-86.6)	68.3% (55.0-79.7)	73.3% (60.3-83.9)
Specificity (95%CI)	59.5% (42.1-75.2)	73.0% (55.9-86.2)	81.1% (64.8-92.0)	75.7% (58.8-88.2)

Abbreviations: AUC, area under the receiver operating characteristic curve; PPV, positive predictive value; NPV, negative predictive value; LOS, length of stay

Two-factor formula: LOS (> 7 days) x 18 + Age (≥ 70 years) x 11, cut-off value ≥ 11

Three-factor formula: LOS (> 7 days) x 16 + Age (≥ 70 years) x 13 + Open surgery x 10, cut-off value ≥ 15

Four-factor formula: LOS (> 7 days) x 16 + Age (≥ 70 years) x 13 + Open surgery x 10 + Surgery duration (> 165 min) x 10, cut-off value ≥ 28

Five-factor formula: LOS (> 7 days) x 16 + Age (≥ 70 years) x 12 + Open surgery x 10 + Surgery duration (> 165 min) x 10 + ASA (≥3) x 6, cut-off value ≥ 27

The presence or absence of each factor is assigned a value of 1 or 0, respectively.

Age has consistently been identified by numerous studies as a predictor of worse surgical outcomes,[5-7, 13-17] with some research also reporting a significant association between longer LOS and functional decline after surgery.[7,15] Conversely, while higher ASA classification, longer operation time, and the distinction between major and minor operations have been recognized by certain studies as factors linked to functional decline or undesirable surgical results,[13,14] other studies have found no such association.[29,30] For instance, a study by Yamaguchi et al. on postoperative functional decline identified higher ASA score and major surgery as contributing factors but found no significant relation between longer operation time and this outcome.[15] In contrast, a study by Zattoni et al. reported no significant association between major operations or higher ASA scores and functional decline.[17]

Nonetheless, a combination of these factors can effectively predict functional decline. Patients of advanced age, particularly those with multiple comorbidities or scheduled for open surgery, should be thoroughly prepared for the physiological stress of surgery. Moreover, patients undergoing prolonged surgeries or extended hospital stays require close monitoring for functional changes to ensure timely interventions and mitigate potential decline. Employing our developed predictive equations can further aid in the early identification of at-risk individuals, enabling the implementation of preventive strategies.

Examining the specific ADLs affected can provide valuable insights for delivering effective strategies to prevent such declines. In the decline group, several BADLs showed significant deterioration, particularly in stair climbing, mobility, bathing, toilet use, and bladder control (Table 3). While surgeries involving the urological system may impact bladder function, the broader decline in other areas indicates challenges related to overall physical mobility. Therefore, implementing strategies to maintain patients' physical capabilities, such as early mobilization, is crucial. Early mobilization is also a core component of the ERAS pathways and has been shown to offer numerous postoperative benefits, including improved physical function, reduced risk of complications, and shorter hospital stays.[31-36]

In terms of IADLs, all aspects except telephone usage were negatively impacted. While this too could partly be attributed to the aforementioned difficulties in mobility, which is reported to be one of the significant predictors of IADLs function,[37] postoperative delirium (POD) might be other aspect to be considered. POD is reported to be one of the factors associated with decreased IADL functionality after surgery.[38-40] However, in our study, through the reviews of medical records we identified only 4 cases (4.1%) of POD, with no statistically significant differences between the functional stable and the decline groups. Future studies with larger sample sizes and standardized POD identification protocols are needed to clarify the relationship between POD and IADL functionality and to establish effective preventive strategies.

As for predicting postoperative functional decline, several strategies have been proposed across different surgical scenarios. Yamaguchi et al. used total psoas muscle volume measured by CT scans to predict decline following emergency abdominal surgery, achieving a good predictive value (AUC = 0.802 from ROC analyses).[15] Another study by Fukuda et al. utilized multiple routine medical data to create complex predictive equations for decline after hip fracture surgery.[16] Two other studies by Zattoni and Hoogerduijn employed screening tools—the Flemish version of the Triage Risk Screening Tool (fTRST) and the Identification of Seniors at Risk-Hospitalized Patients (ISAR-HP)—to predict decline in emergency and cardiac surgery, with AUCs of 0.72 and 0.73, respectively.[17,18]

Nevertheless, to the best of our knowledge, no published study has specifically addressed the prediction of decline following elective abdominal surgery. Based on the risk factors for postoperative functional decline identified in this population, our predictive equations can effectively forecast its occurrence without requiring additional investigations or complex calculations. Given the limited resources, these formulas are valuable tools for healthcare providers. By identifying patients at higher risk of postoperative functional decline, clinicians can prioritize resources for those who are most likely to benefit. This targeted approach could help optimize patient outcomes and enhance overall care quality and efficiency for patients undergoing elective abdominal surgery.

However, our study has several limitations. First, postoperative complications were identified exclusively through medical record reviews, which may limit the completeness of the data. Additionally, participants were reassessed only one month after surgery. Extending the follow-up period could provide valuable insights into the long-term trajectory of patients' functional capacities post-surgery. Third, the data for this study were collected prior to the full implementation of the ERAS pathway at our institution. Future research conducted after its full adoption could provide a clearer picture of how these strategies impact both the incidence and prognosis of functional decline. Lastly, while the developed formulas demonstrated good performance within the studied sample, further validation is necessary to confirm their

broader applicability.

CONCLUSION

More than 60% of Thai older adults undergoing elective abdominal surgery are likely to experience functional decline one month after the procedure. Age ≥ 70 and LOS > 7 days were found to be the factors most strongly associated with this decline. The predictive formulas developed using these factors could be useful for early postoperative risk stratification and guiding timely interventions. These findings highlight the need for proactive measures to mitigate this deterioration and emphasize the importance of tailored strategies to preserve functionality in this population.

Data Availability Statement

The data supporting the findings of this study are not publicly available but can be obtained from the corresponding author upon reasonable request.

ACKNOWLEDGEMENTS

The authors sincerely thank the volunteers who agreed to participate in this study. We acknowledge the invaluable contributions of the Siriraj Integrated Perioperative Geriatric Excellent Research Center. We would also like to thank Mr. Suthipol Udompunthurak and Ms. Julaporn Pooliam, of the Research Group and Research Network Division, Research Department, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand, for providing assistance with statistical analysis.

DECLARATIONS

Grants and Funding Information

This study was funded by a grant from the Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand (Grant Number R016232013).

Conflict of Interest

The researchers claim no conflicts of interest.

Ethics approval

Ethics approval was obtained from the Medical Ethics Committee of the Human research protection unit of the hospital (COA no. 202/2018). All participants gave their written consent to participate.

Author Contributions

Conceptualization: PT, PD; Data curation: PT, SJ, NS; Funding acquisition: PT; Methodology: PT, PD, AS; Project administration: PT; Supervision: PD; Writing – original draft: PT; Writing – review & editing: PT, PD. All authors have read and agreed to the final version of the manuscript.

Use of Artificial Intelligence

ChatGPT-4o was used to check for grammatical errors and improve the readability of this manuscript. The content was subsequently reviewed and edited as needed. The authors take full responsibility for the final version of this publication.

REFERENCES

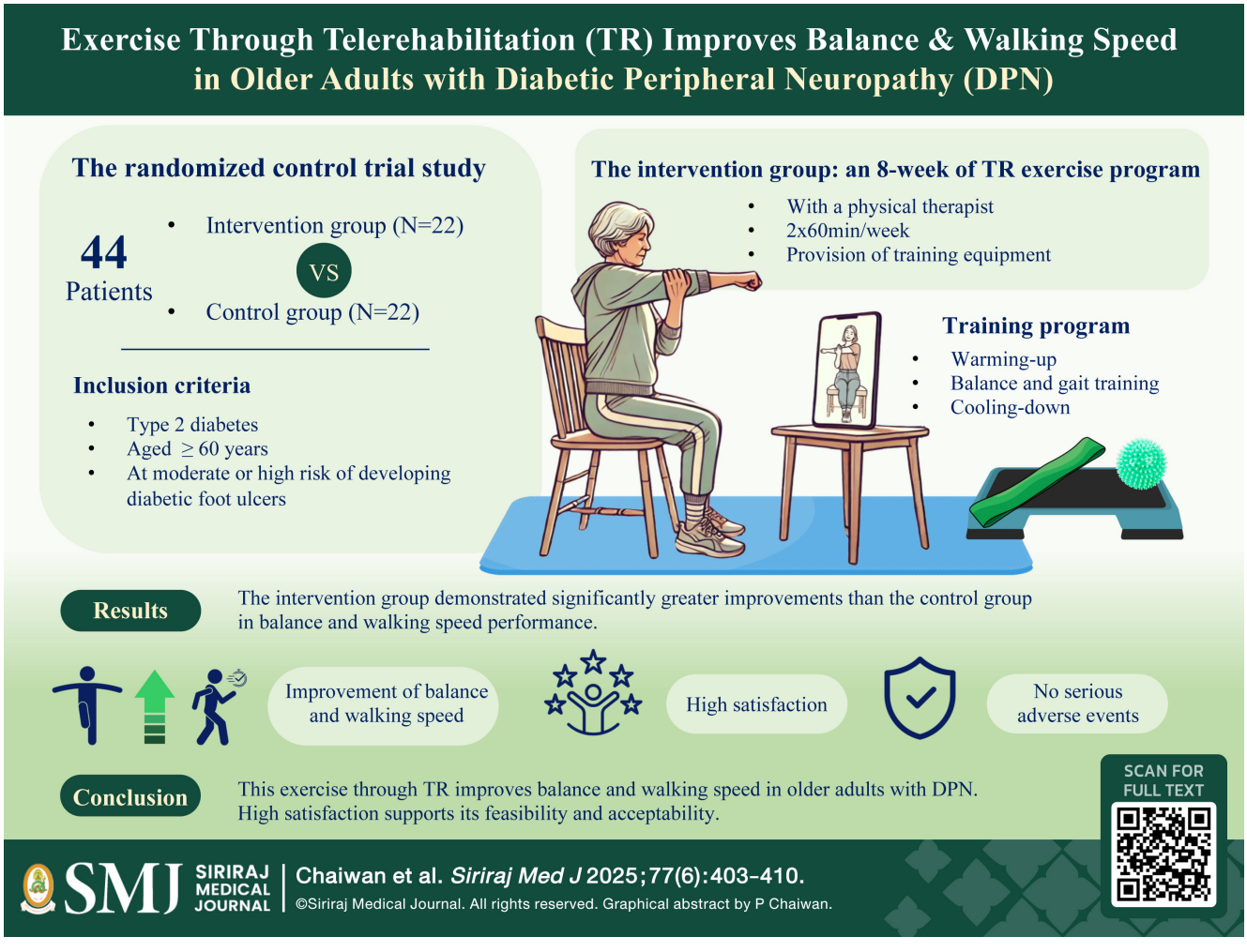
1. Abdulaziz K, Perry JJ, Taljaard M, Emond M, Lee JS, Wilding L, et al. National Survey of Geriatricians to Define Functional Decline in Elderly People with Minor Trauma. Can Geriatr J. 2016;19:2-8.
2. Asakawa T, Koyano W, Ando T, Shibata H. Effects of functional decline on quality of life among the Japanese elderly. Int J Aging Hum Dev. 2000;50:319-28.
3. Suwanabol PA, Li Y, Abrahamse P, De Roo AC, Vu JV, Silveira MJ, et al. Functional and Cognitive Decline Among Older Adults After High-risk Surgery. Ann Surg. 2022;275:e132-e139.
4. Lawrence VA, Hazuda HP, Cornell JE, Pederson T, Bradshaw PT, Mulrow CD, et al. Functional independence after major abdominal surgery in the elderly. J Am Coll Surg. 2004;199:762-72.
5. Robinson TN, Wallace JI, Wu DS, Wiktor A, Pointer LF, Pfister SM, et al. Accumulated frailty characteristics predict postoperative discharge institutionalization in the geriatric patient. J Am Coll Surg. 2011;213:37-42; discussion 42-4.
6. Finlayson E, Zhao S, Boscardin WJ, Fries BE, Landefeld CS, Dudley RA. Functional status after colon cancer surgery in elderly nursing home residents. J Am Geriatr Soc. 2012;60:967-73.
7. Zhang LM, Hornor MA, Robinson T, Rosenthal RA, Ko CY, Russell MM. Evaluation of Postoperative Functional Health Status Decline Among Older Adults. JAMA Surg. 2020;155:950-8.
8. Iglar PJ, Hogan KJ. Vitamin D status and surgical outcomes: a systematic review. Patient Saf Surg. 2015;9:14.
9. Hsu HY, Hwang LC, Lin CH, Lin CJ, Tjung JJ. Impact of serum albumin on functional status and hospital outcome in oldest-old inpatients. Int J Gerontol. 2015;9:220-2.
10. van Stijn MF, Korkic-Halilovic I, Bakker MS, van der Ploeg T, van Leeuwen PA, Houdijk AP. Preoperative nutrition status and postoperative outcome in elderly general surgery patients: a systematic review. JPEN J Parenter Enteral Nutr. 2013;37:37-43.
11. Kotlarczyk MP, Perera S, Ferchak MA, Nace DA, Resnick NM, Greenspan SL. Vitamin D deficiency is associated with functional decline and falls in frail elderly women despite supplementation. Osteoporos Int. 2017;28:1347-53.
12. Arnau A, Espaulella J, Serrarols M, Canudas J, Formiga F, Ferrer M. Risk factors for functional decline in a population aged 75 years and older without total dependence: A one-year follow-up. Arch Gerontol Geriatr. 2016;65:239-47.
13. Simões CM, Carmona MJC, Hajjar LA, Vincent JL, Landoni G, Belletti A, et al. Predictors of major complications after elective abdominal surgery in cancer patients. BMC Anesthesiol. 2018;18:49.
14. Hacim NA, Akbas A, Ulgen Y, Aktokmakyan TV, Meric S,

Tokocin M, et al. Association of Preoperative Risk Factors and Mortality in Older Patients following Emergency Abdominal Surgery: A Retrospective Cohort Study. Ann Geriatr Med Res. 2021;25:252-9.
15. Yamaguchi K, Matsumoto S, Abe T, Nakajima K, Senoo S, Shimizu M, et al. Predictive value of total psoas muscle index for postoperative physical functional decline in older patients undergoing emergency abdominal surgery. BMC Surg. 2023;23:171.
16. Fukuda T, Imai S, Maruo K, Horiguchi H. A formula for predicting postoperative functional decline using routine medical data in elderly patients after hip fracture surgery. Curr Orthop Pract. 2023;34:208-14.
17. Zattoni D, Montroni I, Saur NM, Garutti A, Bacchi Reggiani ML, Ghignone F, et al. Prediction of functional loss in emergency surgery is possible with a simple frailty screening tool. World J Emerg Surg. 2021;16:12.
18. Hoogerduijn JG, de Rooij SE, Grobbee DE, Schuurmans MJ. Predicting functional decline in older patients undergoing cardiac surgery. Age Ageing. 2014;43:218-21.
19. Kleyweg RP, van der Meche FG, Schmitz PI. Interobserver agreement in the assessment of muscle strength and functional abilities in Guillain-Barre syndrome. Muscle Nerve. 1991;14: 1103-9.
20. Jones CJ, Rikli RE, Beam WC. A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. Res Q Exerc Sport. 1999;70:113-9.
21. Mahoney FI, Barthel DW. Functional Evaluation: The Barthel Index. Md State Med J. 1965;14:61-5.
22. Laohaprasitiporn P, Jarusriwanna A, Unnanuntana A. Validity and Reliability of the Thai Version of the Barthel Index for Elderly Patients with Femoral Neck Fracture. J Med Assoc Thai. 2017;100:539.
23. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist. 1969;9:179-86.
24. Train the Brain Forum Committee. Thai mental state examination (TMSE). Siriraj Hosp Gaz. 1993;45:661-74.
25. Kaiser MJ, Bauer JM, Ramsch C, Uter W, Guigoz Y, Cederholm T, et al. Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. J Nutr Health Aging. 2009;13:782-8.
26. Lotrakul M, Sumrithe S, Saipanish R. Reliability and validity of the Thai version of the PHQ-9. BMC Psychiatry. 2008;8:46.
27. Jakobson T, Karjagin J, Vipp L, Padar M, Parik AH, Starkopf L, et al. Postoperative complications and mortality after major gastrointestinal surgery. Medicina (Kaunas). 2014;50:111-7.
28. Nahm FS. Receiver operating characteristic curve: overview and practical use for clinicians. Korean J Anesthesiol. 2022;75: 25-36.
29. Tan HL, Chia STX, Nadkarni NV, Ang SY, Seow DCC, Wong TH. Frailty and functional decline after emergency abdominal surgery in the elderly: a prospective cohort study. World J Emerg Surg. 2019;14:62.
30. Honda Y, Takahashi K, Sasanuma N, Itani Y, Nagase M, Uchiyama Y, et al. Predictors of Functional Decline in Activities of Daily Living at Discharge in Patients After Cardiovascular Surgery. Circ J. 2021;85:1020-6.
31. Kanejima Y, Shimogai T, Kitamura M, Ishihara K, Izawa KP. Effect of Early Mobilization on Physical Function in Patients after Cardiac Surgery: A Systematic Review and Meta-Analysis. Int J Environ Res Public Health. 2020;17(19):7091.
32. Tazreean R, Nelson G, Twomey R. Early mobilization in enhanced recovery after surgery pathways: current evidence and recent advancements. J Comp Eff Res. 2022;11:121-9.
33. Epstein NE. A review article on the benefits of early mobilization following spinal surgery and other medical/surgical procedures. Surg Neurol Int. 2014;5:S66-73.
34. Hu Y, McArthur A, Yu Z. Early postoperative mobilization in patients undergoing abdominal surgery: a best practice implementation project. JBI Database System Rev Implement Rep. 2019;17:2591-611.
35. Heng G, Lohsiriwat V, Tan K-Y. Suitability of Enhanced Recovery after Surgery (ERAS) Protocols for Elderly Colorectal Cancer Patients. Siriraj Med J. 2020;72:18-23.
36. Somnuke P, Pongraweewan O, Siriussawakul A. Optimizing Perioperative Care for Elderly Surgical Patients: A Review of Strategies and Evidence-Based Practices. Siriraj Med J. 2024;76: 465-72.
37. Bruderer-Hofstetter M, Gorus E, Cornelis E, Meichtry A, De Vriendt P. Influencing factors on instrumental activities of daily living functioning in people with mild cognitive disorder - a secondary investigation of cross-sectional data. BMC Geriatr. 2022;22:791.
38. Rudolph JL, Inouye SK, Jones RN, Yang FM, Fong TG, Levkoff SE, et al. Delirium: an independent predictor of functional decline after cardiac surgery. J Am Geriatr Soc. 2010;58:643-9.
39. Liang CK, Chu CL, Chou MY, Lin YT, Lu T, Hsu CJ, et al. Interrelationship of postoperative delirium and cognitive impairment and their impact on the functional status in older patients undergoing orthopaedic surgery: a prospective cohort study. PLoS One. 2014;9:e110339.
40. Suraarunsumrit P, Pathonsmith C, Srinonprasert V, Sangarunakul N, Jiraphorncharas C, Siriussawakul A. Postoperative cognitive dysfunction in older surgical patients associated with increased healthcare utilization: a prospective study from an upper-middle-income country. BMC Geriatr. 2022;22:213.

Effects of Exercise Through Telerehabilitation on Balance and Walking Speed in Older Adults with Diabetic Peripheral Neuropathy: A Randomized Controlled Trial

Pilipda Chaiwan, M.Sc.[1], Gulapar Srisawasdi, M.D.[1,*], Pannika Prachgosin, M.D.[2], Paweena Aekwattanaphol, M.Sc.[1], Nathanit Jirapongpathai, M.Sc.[1]

[1]Sirindhorn School of Prosthetics and Orthotics (SSPO), Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand, [2]Department of Rehabilitation Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.



**Corresponding author: Gulapar Srisawasdi*
E-mail: gulapar.pho@mahidol.edu
Received 11 December 2024 Revised 9 February 2025 Accepted 9 February 2025
ORCID ID: http://orcid.org/0009-0002-0053-6684
https://doi.org/10.33192/smj.v77i6.272555

ABSTRACT

Objective: Determine the effects of exercise through telerehabilitation (TR) on balance and walking speed in older adults with diabetic peripheral neuropathy (DPN).

Materials and Methods: An observer blinded randomized controlled trial was conducted at Sirindhorn School of Prosthetics and Orthotics. Participants age ≥60 years with type 2 diabetes, DPN, and a moderate to high risk of diabetic foot ulcer were randomly assigned to an intervention group who underwent an eight-week TR exercise program (2 x 60 min/week) and a control group who received standard hospital care. Outcome measures were balance (Berg Balance Scale, BBS), walking speed (10-Meter Walk Test, 10MWT), and satisfaction. Differences in change between the groups were analyzed using Mann Whitney U (MWU) test or t-test for independent samples.

Results: Forty-four participants were included (intervention: n=22; control: n=22), with 18 and 21 completing the study, respectively. The median age [IQR] was 69.5 [63, 72.8] years in the intervention group and 67 [65, 74] years in the control group. No differences between groups were found in baseline characteristics and initial outcomes. The intervention group demonstrated significantly greater improvements than the control group in BBS scores (median change [IQR]: 6.5 [4.8, 5.2] vs. -1 [-1, -2], P<0.001, MWU test) and 10MWT time (mean change -1.9 seconds [95% CI: -2.5, -1.3] vs. -0.1 seconds [95% CI: -0.5, 0.4], P<0.001, independent t-test). The intervention group was highly satisfied with the program.

Conclusion: This exercise through TR improves balance and walking speed in older adults with DPN. High satisfaction supports its feasibility and acceptability.

Keywords: Balance; diabetes; exercise; telerehabilitation; walking speed (Siriraj Med J 2025; 77: 403-410)

INTRODUCTION

According to the International Diabetes Federation 2021, diabetes is a rapidly escalating global health crisis in the 21st century. The report estimated that around 537 million adults (20-79 years) were living with diabetes in 2021, which is estimated to increase to 643 million by 2030, and 783 million by 2045.[1] Type 2 diabetes (T2DM) is the most prevalent type of diabetes, representing about 90% of all diabetes cases worldwide.[2] One of the most prevalent chronic complications of diabetes is diabetic peripheral neuropathy (DPN), characterized by paresthesia, especially in the feet and hands.[3] DPN can lead to decreased proprioception[4], reduced foot-ankle range of motion, and diminished muscle strength[5,6], resulting in impaired postural stability, functional gait, and balance. These impairments significantly increase the risk of falls, especially in older adults. Moreover, DPN is a major cause of foot ulceration and amputation.[7-10]

Exercise has been an essential aspect of non-pharmacological treatment for DPN.[11] Evidence suggests that exercise programs, including walking, balance training, and lower limb strengthening exercises, can decrease the risk of falls in older adults with DPN.[12-16] However, many patients are unable to participate in the offered exercise programs due to barriers such as long-distance travel or work commitments.[17] During the COVID-19 pandemic, physical therapists (PTs) adapted their practices to maintain rehabilitation services while adhering to healthcare safety measures. Some PTs began implementing telerehabilitation (TR).[18] TR, a system to manage or monitor remote rehabilitation through communication technologies might be an option.[19] This approach not only saves time and resources in healthcare, but also provides convenience and flexibility, allowing information to reach a broader audience, including those in remote areas.[19,20]

Therefore, we developed an exercise program for balance and gait training, amid the COVID-19 pandemic. This program was delivered through TR and supervised by a PT. Thus, this study aimed to analyze effects of TR-based exercise program on balance and walking speed in older adults with DPN compared to no intervention.

MATERIALS AND METHODS

Research design

This observer-blinded randomized controlled trial was conducted at the Sirindhorn School of Prosthetics and Orthotics (SSPO), Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand, between October 2021 and January 2024. The study conformed to the guidelines of the Declaration of Helsinki was approved by the Siriraj Institutional Review Board with a certificate of approval (COA) no. Si 821/2021. After informed consent participants were randomly assigned to an intervention group or a control group. Randomization was conducted by an independent researcher using a computer-generated

randomization list to ensure allocation concealment. Participants were assigned to their respective groups based on the sequential order of the randomization list.

Participants

Patients with T2DM were recruited from the diabetic foot clinic at SSPO and the Siriraj Diabetes Center of Excellence, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok by clinical staff. Included were people, 1) diagnosed with T2DM and DPN at moderate or high risk of developing diabetic foot ulcers (DFU) as diagnosed by physicians[21]; 2) 60 years or older; 3) capable of walking and exercising independently without the need for assistive devices; 4) having a caregiver or someone present while exercising at home; 5) capable of using a smartphone or laptop for the TR program. Excluded were people with 1) an active foot ulcer; 2) baseline Berg Balance Scale (BBS) score below 45; 3) history of amputations; 4) orthopedic or surgical issues in the lower extremities such as fractures, malformations, or severe osteoarthritis; 5) presence of other neurological impairments, central nervous system problems, or vestibular system disorders; 6) severe retinopathy and/or nephropathy; 7) severe cardiopulmonary conditions or abnormal electrocardiogram results; 8) postural hypotension or uncontrolled hypertension; 9) poor vision; 10) intellectual disabilities or psychiatric disorders.

Intervention

All exercises included in the training program are described in Supplementary Material (https://doi.org/10.6084/m9.figshare.27991079.v3). The training program, partly based on previous studies[15,16], was developed by our team to enhance balance and gait training in a TR setting. Two PTs participated in this study. An observer, blinded to group allocation assessed pre- and post-intervention outcomes. A PT administered the exercises through TR. Participants in the intervention group received logbook that included the home-based exercise program as well as educational materials for self-care. Individuals accessed TR services through an online platform (LINE application) with the PT. Training time was 60 minutes, twice a week for 8 weeks on non-consecutive days. During training, the participants wore sport shoes or therapeutic shoes, which are custom-made to protect sensitive feet, reduce pressure, and provide support for patients' conditions, prescribed by a physician and worn with socks. The standardized training equipment consisted of 1) a training mat, 2) a sensory massage ball, diameter of 7.5 cm, 3) a lightweight elastic band, and 4) a step board size 28x78x20 cm. The training program was structured into three components: warming-up, balance and gait training, and cooling-down (Table 1).

Participants in the control group did not receive an exercise program, but received usual hospital medical care. In addition, both groups received pamphlets written by interdisciplinary teams at Siriraj Diabetes Center of Excellence covering topics such as diabetic foot care, diabetic diet, and diabetes complications.

Outcome measures

All participants were assessed using the Berg Balance Scale (BBS) and the 10 Meter Walk Test (10MWT) by the observer at baseline (T0) and after an 8-week follow-up (T1). Furthermore, during the final evaluation, the intervention group filled in a satisfaction questionnaire.

The BBS assesses static and dynamic balance capabilities and it consists of 14 items, each item is graded on a five-point scale (0 to 4) based on the quality of the performance of the item. The maximum score is 56. A score below 45 indicates a higher risk of falling.[8,22] The tool demonstrates responsiveness to changes in balance.

The 10MWT measures the time needed to walk a distance of 10 meters on a 14-meter walkway. The participants walked at a comfortable speed. The mean time (in seconds) of three trials was analyzed, with a 2-minute rest between each trial.[23]

Assessment of satisfaction concerning the exercise program, included six items (1) How would you rate the appropriateness of the duration of each training session, around 1 hour?, (2) How would you rate the quality of the training and equipment?, (3) Did the physical therapist explain the exercises in a way that was easy to understand?, (4) Do you feel that the physical therapist treated you with respect and dignity?, (5) Would you recommend this exercise program to a friend or family member?, (6) How would you rate the overall quality of the program delivered via an online platform? These items could be rated as; 1 = unsatisfied, 2 = poor, 3 = fair, 4 = good, or 5 = excellent.

Sample size calculation

The sample size calculation for this study was calculated using G*Power software, based on a randomized controlled trial with a 1:1 ratio of intervention group and control group.[16] That study reported a mean change of 2.1 for the intervention group and 0.1 for the control group in BBS outcomes, with standard deviations (SD) of 2.3 for both groups Assuming a power of 80% and an alpha of 0.05, the resulting effect size was 0.87. The required sample size was 44 participants, with 22 participants per group.

TABLE 1. Outline of the Siriraj Exercise Protocol.

Exercise	Composition
Warming-up (10 minutes)	Stretching: Neck muscles, posterior shoulder, triceps brachii stretch with side bend, hamstrings, gluteus and lower back, quadriceps, calf (10 seconds/3reps/side)
Balance and gait training (40 minutes)	Part 1: Balance training on a training mat - Bipedal heel and toe raise (10 reps/3 sets) - One-leg stance (10 seconds/3 reps/side) Rest: Sitting on a chair with a resistance band exercise (10 reps/3 sets) - Chest press - Middle back band pull-apart Part 2: Progressive balance and gait training on a training mat - Tandem stance (10 seconds/10 reps/side) - Backward walking (10 reps) - Sideways walking (10 reps/side) Part 3: Exercises on a step board (10 reps/direction/side) - Step-ups: front step-ups and side step-ups - Weight shifting: forward and side-to-side
Cooling-down (10 minutes)	- Sensory ball massaging (10 reps/side) - Foot writing the number 1 to 10 in the air (10 reps/side) - Towel curl (10 reps/3 sets) - Deep breathing (5 reps)

Abbreviation: Reps = repetitions

Statistical analysis

Statistical analyzes were performed using IBM SPSS Statistics, Version 29.0.2.0. The Shapiro-Wilk test was employed to assess the normality of the distribution for all parameters. Baseline differences between groups were evaluated using Student's *t* test or the Mann-Whitney *U* test for continuous variables and the Chi-square test for categorical variables. Differences in changes between groups were analyzed using an independent samples t-test or Mann-Whitney U test depending on data distribution. A significance level of $P < 0.05$ was considered statistically significant for all tests.

RESULTS

Forty-eight individuals were assessed for eligibility, and a total of forty-four participants were randomized into either the intervention group (n=22) or the control group (n=22). Finally, 18 participants in the intervention group and 21 participants in the control group were analyzed (Fig 1). There were no significant differences in the baseline characteristics between the two groups ($P>0.05$) (Table 2). No serious adverse events of the programs were reported.

Berg balance scale

The improvement in the BBS were significantly larger in the intervention group, (median change [IQR]: 6.5 [4.8, 5.2] than the control group (median change [IQR]: -1 [-1, -2]), P<0.001, MWU test (Table 3).

10 Meter walk test

The improvements in 10MWT were significantly larger in the intervention group (mean change -1.9 seconds [95% CI: -2.5, -1.3]) than the control group (mean change -0.1 seconds [95% CI: -0.5, 0.4]), P<0.001, independent t-test) (Table 3).

The satisfaction with the exercise program

Among the 18 participants who completed the survey, 17 rated the duration of each training session as

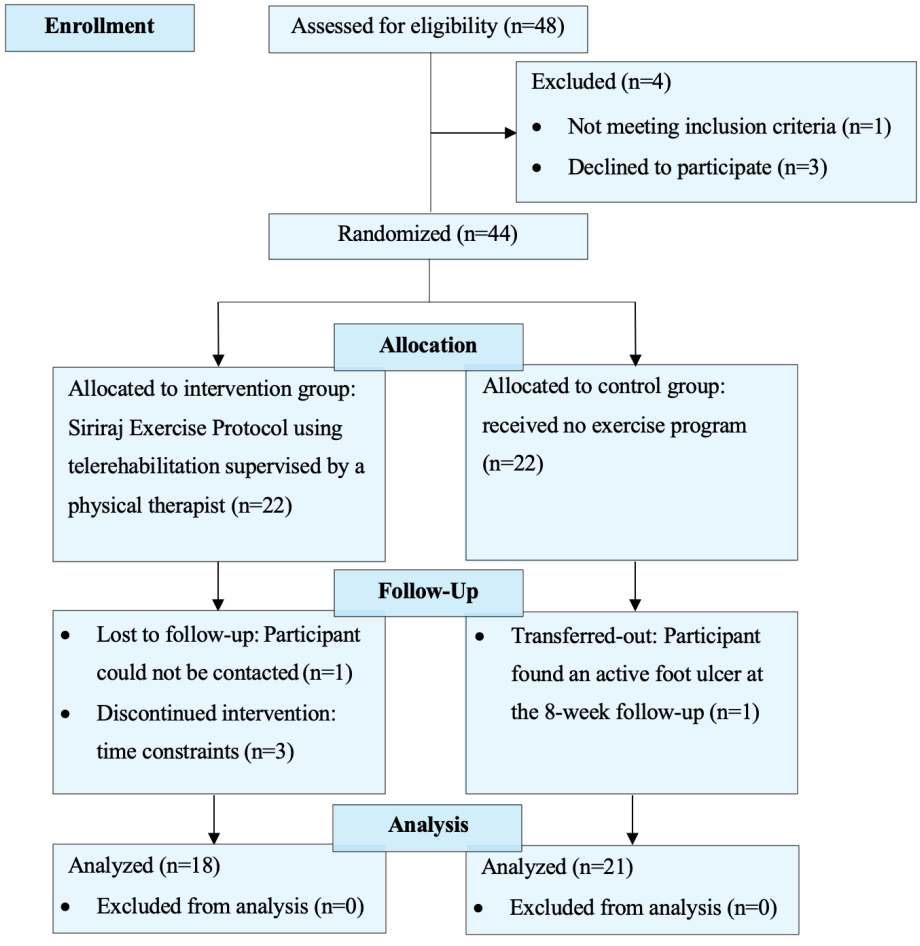


Fig 1. Flow diagram of the study.

excellent. 16 rated the quality of training and equipment as excellent, and 17 reported that the PT explained the exercises in a way that was easy to understand with excellent. All participants felt they were treated with respect and dignity by the PT. Additionally, 16 of participants would recommend this exercise program to a friend or family member, and 17 rated the overall quality of the program through the online platform as excellent.

DISCUSSION

This exercise program delivered by a PT via TR resulted in significant improvements in balance and walking speed in older adults with DPN. In the control group BBS score deteriorated highlighting the negative impact of physical inactivity or insufficient exercise. This result is consistent with previous findings that older adults with T2DM rapidly decline in leg muscle strength and muscle quality.[24]

Throughout the 8-week of training, no serious adverse events or diabetic foot ulcers were observed among participants in the intervention group. This finding challenges the historical advice for people with DPN to reduce weight-bearing activity.[25] However, lack of physical activity can result in deterioration of skin health and decrease in total body tolerance.[26,27] A previous study confirmed that weight-bearing exercises significantly improved daily step count and 6-minute walk test compared to non-weight-bearing exercises.[28] Moreover, increased weight-bearing activity did not lead to an increased risk of re-ulceration in diabetic foot.[29]

In this study, we selected an 8-week, twice-weekly training program based on the findings of a previous study, which reported significant improvements in balance and trunk proprioception were found following an on-site training.[16] We delivered our program through TR, highlighting the potential of remote training to achieve similar benefits.

To improve balance performance, balance exercises should be performed 2-3 days a week to enhance postural ability and gait, thereby reducing the risk of falling. Stretching exercises should be performed to the point of tightness for 10-30 seconds with 2-4 repetitions to improve joint range of motion.[30] The American Diabetes Association[31] guidelines emphasize the importance of regular exercise for older adults managing T2DM to promote overall physical function and prevent mobility-related complications.

TABLE 2. Baseline characteristics of both groups.

Characteristic	Intervention Group (n=18)	Control Group (n=21)	*P*
Age (y), median [IQR]	69.5 [63, 72.8]	67 [65, 74]	0.944†
Sex			1.000
Men, n (%)	6 (33%)	7 (33%)	
Women, n (%)	12 (67%)	14 (67%)	
Height (cm), mean ± SD	160.5 ± 8.4	157.9 ± 6.7	0.282*
Weight (kg), median [IQR]	64.9 [60, 81.5]	62 [57, 68]	0.118†
Body mass index (kg/m^2), mean ± SD	27.3 ± 5.2	25 ± 4.0	0.132*
Fasting blood glucose (mg/dL), median [IQR]	134.5 [122.5, 153]	129 [115, 150]	0.278†
Diabetes duration (y), median [IQR]	15 [10, 26.5]	23 [14, 30]	0.525†
Number of falls (n), median [IQR]	2 [1, 3.8]	1 [1, 3]	0.201†
The risk of foot ulceration			0.173
Moderate risk, n (%)	8 (44%)	5 (24%)	
High risk, n (%)	10 (56%)	16 (76%)	
Medication			0.233
Oral hypoglycemic agent, n (%)	13 (72%)	12 (57%)	
Insulin injection, n (%)	0	3 (14%)	
Both, n (%)	5 (28%)	6 (29%)	
Smoking			1.000
Yes, n (%)	1 (6%)	1 (5%)	
No, n (%)	17 (94%)	20 (95%)	

* Result of Student *t* test.
† Result of Mann-Whitney U test; otherwise by Chi-square test.

TABLE 3. Results of the Berg Balance Scale (BBS) and the 10 Meter Walk Test (10MWT) evaluated baseline and 8-week follow-up within the group.

Outcomes	Intervention group		Control group		Intervention group	Control group	*P* Value of difference in change between groups
	T0	T1	T0	T1	Change	Change	
BBS (score) (median [IQR])	48.5 [47, 50.8] NS	55 [51.8, 56]	47 [46, 50] NS	46 [45, 48]	6.5 [4.8, 5.2]	-1 [-1, -2]	<0.001†
10MWT (second) (mean ± SD)	11.8 ± 3.6 NS	9.9 ± 3.3	12.8 ± 3.4 NS	12.8 ± 3.5	-1.9 [95%CI: -2.5, -1.3]	-0.1 [95%CI: -0.5, 0.4)	<0.001*

T0 = at baseline, T1 = at 8 weeks of follow-up, BBS = Berg Balance Scale, 10MWT = 10 Meter Walk Test.
NS = Not significant difference at baseline between groups (P > 0.05).
† Result of the Mann-Whitney *U* test.
* Result of Student's paired *t* test.

Improved walking speed is critical to maintaining functional mobility and independence in older adults. Brisk walking (4-8 km/hour) significantly increases the chance of maintaining in functional mobility and independence in T2DM compared to slower paces.[32] In this study, the intervention group showed an improvement in walking speed (10MWT) from 3.1 km/hour to 3.6 km/hour but that is still speed that is less than the desirable speed of 4 km/hour.

Our study utilized TR intervention delivered through real-time video conferencing, allowing participants to receive direct supervision and feedback from the PT. This approach enabled participants to maintain social distancing during the pandemic while continuing supervised exercise at home. The program is simple and uses affordable equipment, easy to implement, and suitable for home-based settings. Furthermore, the high satisfaction reported in the survey supports the feasibility and acceptability of this exercise program among participants. Similarly, a recent study reported that a 6-week (3 times/week) supervised home-based TR program combining aerobic and resistance exercises significantly improved glycemic control, six-minute walk test performance, muscle strength, and quality of life in patients with T2DM. TR addresses barriers to exercise participation by being accessible, making it a viable alternative to traditional in-person programs.[33]

This study has several limitations. First, the sample size was below the estimated target. The inclusion criteria required older adults to be able to use a smartphone for TR, which posed challenges for some participants due to technological difficulties and the COVID-19 situation, caused temporary research pauses. Second, the study duration was limited to 8 weeks, which may not capture the long-term effects of the intervention. Future studies should include larger sample sizes and longer follow-up periods to assess the sustainability of the observed improvements. Third, the control group received only standard hospital care. Future studies should consider another intervention such as those participating in alternative home-based exercise programs (e.g., cycling on a home trainer), to assess whether similar improvements could be achieved with other intervention designs.

CONCLUSION

This exercise program through TR increases balance and walking speed in older adults with DPN. The high levels of participant satisfaction further support its feasibility and acceptability. These findings suggest that TR could be a valuable tool in the management of DPN, offering a flexible and accessible approach to rehabilitation.

Data Availability Statement

The data of this study and details regarding the exercise program are available on Figshare at https://doi.org/10.6084/m9.figshare.27991079.v3.

ACKNOWLEDGMENTS

The authors sincerely thank the patients and families for their vital participation. Appreciation also goes to the Siriraj Diabetes Center of Excellence, Faculty of Medicine Siriraj Hospital for participant recruitment support and to Miss Nerisa Thornsri for her invaluable help with statistical analyses.

DECLARATION

Grants and Funding Information

This study was supported by Siriraj Research Fund, Faculty of Medicine Siriraj Hospital, Mahidol University, Grant Number (IO) R016531010 and Partial Funding Proposal for Research Grant 2021 by Graduate Studies of Mahidol University Alumni Association and Faculty of Graduate Studies.

Conflict of Interest

No potential conflict of interest was reported by the authors.

Registration Number of Clinical Trial

This study protocol was not registered in a trial registry.

Author Contributions

Conceptualization and methodology, P.C., G.S., P.P., and P.A. ; Provision of patients, N.J. ; Data collection and data acquisition, P.C. and P.A. ; Formal analysis, P.C. and G.S. ; Visualization and writing – original draft, P.C. ; Writing – review and editing, G.S. ; Supervision, G.S. and P.P. All authors - Final approval of the version to be published.

Use of Artificial Intelligence

No artificial intelligence tools were used in the writing of this research.

REFERENCES

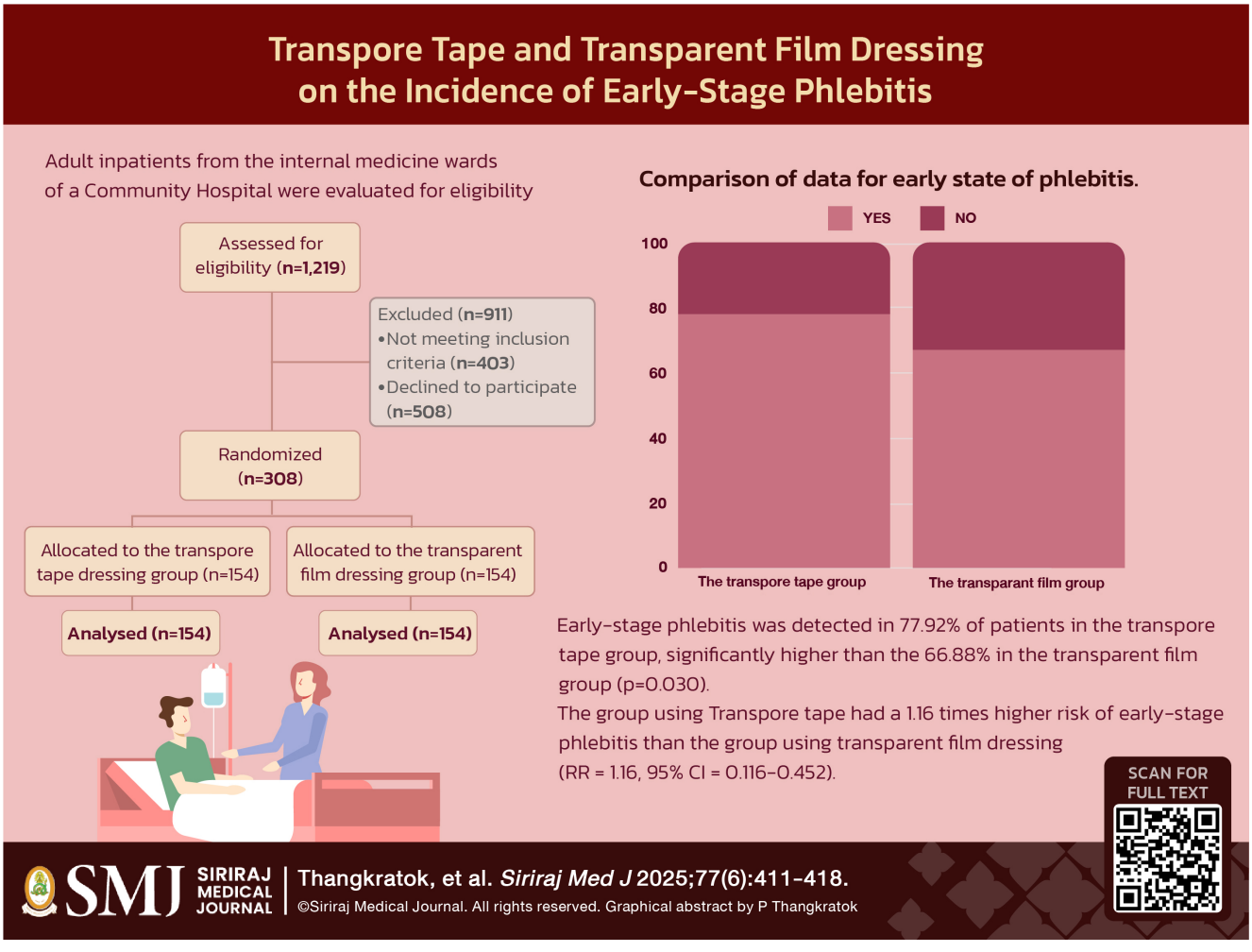
1. Magliano DJ, Boyko EJ, committee IDFDAtes. IDF DIABETES ATLAS. 10th ed: International Diabetes Federation, Brussels; 2021.
2. Liu J, Bai R, Chai Z, Cooper ME, Zimmet PZ, Zhang L. Low- and middle-income countries demonstrate rapid growth of type 2 diabetes: an analysis based on Global Burden of Disease 1990-2019 data. Diabetologia. 2022;65(8):1339-52.
3. Win MMTM, Fukai K, Nyunt HH, Linn KZ. Hand and foot exercises for diabetic peripheral neuropathy: A randomized

controlled trial. Nurs Health Sci. 2020;22(2):416-26.
4. Ahmad I, Verma S, Noohu MM, Shareef MY, Hussain ME. Sensorimotor and gait training improves proprioception, nerve function, and muscular activation in patients with diabetic peripheral neuropathy: a randomized control trial. J Musculoskelet Neuronal Interact. 2020;20(2):234-48.
5. Monteiro RL, Sartor CD, Ferreira JS, Dantas MG, Bus SA, Sacco IC. Protocol for evaluating the effects of a foot-ankle therapeutic exercise program on daily activity, foot-ankle functionality, and biomechanics in people with diabetic polyneuropathy: A randomized controlled trial. BMC Musculoskelet Disord. 2018;19:1-12.
6. Martinelli AR, Mantovani AM, Nozabieli AJ, Ferreira DM, Barela JA, Camargo MR, et al. Muscle strength and ankle mobility for the gait parameters in diabetic neuropathies. Foot (Edinb). 2013;23(1):17-21.
7. Venkataraman K, Tai BC, Khoo EYH, Tavintharan S, Chandran K, Hwang SW, et al. Short-term strength and balance training does not improve quality of life but improves functional status in individuals with diabetic peripheral neuropathy: a randomised controlled trial. Diabetologia. 2019;62(12):2200-10.
8. Timar B, Timar R, Gaiță L, Oancea C, Levai C, Lungeanu D. The impact of diabetic neuropathy on balance and on the risk of falls in patients with type 2 diabetes mellitus: a cross-sectional study. PloS One. 2016;11(4):e0154654.
9. Vongsirinavarat M, Kraiwong R. Falls among Older People with Type 2 Diabetes Mellitus with Peripheral Neuropathy. Siriraj Med J. 2021;73(2):92-8.
10. Selvarajah D, Kar D, Khunti K, Davies MJ, Scott AR, Walker J, et al. Diabetic peripheral neuropathy: advances in diagnosis and strategies for screening and early intervention. Lancet Diabetes Endocrinol. 2019;7(12):938-48.
11. de Oliveira Lima RA, Piemonte GA, Nogueira CR, Dos Santos Nunes-Nogueira V. Efficacy of exercise on balance, fear of falling, and risk of falls in patients with diabetic peripheral neuropathy: a systematic review and meta-analysis. Arch Endocrinol Metab. 2021;65(2):198-211.
12. Allet L, Armand S, de Bie RA, Golay A, Monnin D, Aminian K, et al. The gait and balance of patients with diabetes can be improved: a randomised controlled trial. Diabetologia. 2010;53(3):458-66.
13. Richardson JK, Sandman D, Vela S. A focused exercise regimen improves clinical measures of balance in patients with peripheral neuropathy. Arch Phys Med Rehabil. 2001;82(2):205-9.
14. Gu Y, Dennis SM. Are falls prevention programs effective at reducing the risk factors for falls in people with type-2 diabetes mellitus and peripheral neuropathy: A systematic review with narrative synthesis. J Diabetes Complications. 2017;31(2):504-16.
15. Lee K, Lee S, Song C. Whole-body vibration training improves balance, muscle strength and glycosylated hemoglobin in elderly patients with diabetic neuropathy. Tohoku J Exp Med. 2013;231(4):305-14.
16. Song CH, Petrofsky JS, Lee SW, Lee KJ, Yim JE. Effects of an exercise program on balance and trunk proprioception in older adults with diabetic neuropathies. Diabetes Technol Ther. 2011;13(8):803-11.
17. Duruturk N. Telerehabilitation intervention for type 2 diabetes. World J Diabetes. 2020;11(6):218-26.
18. Buabbas AJ, Albahrouh SE, Alrowayeh HN, Alshawaf H. Telerehabilitation during the COVID-19 Pandemic: Patients and Physical Therapists' Experiences. Med Princ Pract. 2022;31(2):156-64.
19. Seron P, Oliveros M-J, Gutierrez-Arias R, Fuentes-Aspe R, Torres-Castro RC, Merino-Osorio C, et al. Effectiveness of Telerehabilitation in Physical Therapy: A Rapid Overview. Phys Ther. 2021;101(6):pzab053.
20. Connelly J, Kirk A, Masthoff J, MacRury S. The use of technology to promote physical activity in Type 2 diabetes management: a systematic review. Diabet Med. 2013;30(12):1420-32.
21. Sarinnapakorn V, Sunthorntepwarakul T, Deerochanawong C, Niramitmahapanya S, Napartivaumnuay N. Prevalence of diabetic foot ulcers and risk classifications in type 2 diabetes mellitus patients at Rajavithi Hospital. J Med Assoc Thai. 2016;99(2):S99-S105.
22. Bogle Thorbahn LD, Newton RA. Use of the Berg Balance Test to predict falls in elderly persons. Phys Ther. 1996;76(6):576-83; discussion 84-5.
23. Steffen TM, Hacker TA, Mollinger L. Age- and Gender-Related Test Performance in Community-Dwelling Elderly People: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and Gait Speeds. Phys Ther. 2002;82(2):128-37.
24. Park SW, Goodpaster BH, Strotmeyer ES, Kuller LH, Broudeau R, Kammerer C, et al. Accelerated loss of skeletal muscle strength in older adults with type 2 diabetes: the health, aging, and body composition study. Diabetes Care. 2007;30(6):1507-12.
25. Sigal RJ, Kenny GP, Wasserman DH, Castaneda-Sceppa C, White RD. Physical activity/exercise and type 2 diabetes: a consensus statement from the American Diabetes Association. Diabetes Care. 2006;29(6):1433-8.
26. Mueller MJ, Maluf KS. Tissue adaptation to physical stress: a proposed "Physical Stress Theory" to guide physical therapist practice, education, and research. Phys Ther. 2002;82(4):383-403.
27. Dajpratham P, Thitisakulchai P, Pongratanakul R, Prapavanond R, Haridravedh S, Muangpaisan W. Effectiveness of Personalized Multifactorial Fall Risk Assessment and Intervention in Reducing Fall Rates Among Older Adults: A Retrospective Study. Siriraj Med J. 2025;77(1):64-72.
28. Mueller MJ, Tuttle LJ, Lemaster JW, Strube MJ, McGill JB, Hastings MK, et al. Weight-bearing versus nonweight-bearing exercise for persons with diabetes and peripheral neuropathy: a randomized controlled trial. Arch Phys Med Rehabil. 2013;94(5):829-38.
29. Lemaster JW, Reiber GE, Smith DG, Heagerty PJ, Wallace C. Daily weight-bearing activity does not increase the risk of diabetic foot ulcers. Med Sci Sports Exerc. 2003;35(7):1093-9.
30. Colberg SR, Sigal RJ, Yardley JE, Riddell MC, Dunstan DW, Dempsey PC, et al. Physical Activity/Exercise and Diabetes: A Position Statement of the American Diabetes Association. Diabetes Care. 2016;39(11):2065-79.
31. Standards of Care in Diabetes-2023 Abridged for Primary Care Providers. Clin Diabetes. 2022;41(1):4-31.
32. Jayedi A, Zargar MS, Emadi A, Aune D. Walking speed and the risk of type 2 diabetes: a systematic review and meta-analysis. Br J Sports Med. 2024;58(6):334-42.
33. Blioumpa C, Karanasiou E, Antoniou V, Batalik L, Kalatzis K, Lanaras L, et al. Efficacy of supervised home-based, real time, videoconferencing telerehabilitation in patients with type 2 diabetes: a single-blind randomized controlled trial. Eur J Phys Rehabil Med. 2023;59(5):628-39.

Transpore Tape and Transparent Film Dressing on the Incidence of Early-Stage Phlebitis: A Comparative Randomized Trial

Pramote Thangkratok, Ph.D.[1,*], Krit Pongpirul, Ph.D.[1,2,3,4,5,6], Jiruth Sriratanaban, Ph.D.[1]

[1]Department of Preventive and Social Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand, [2]Center of Excellence in Preventive and Integrative Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand, [3]School of Global Health and Department of Preventive and Social Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand, [4]Clinical Research Center, Bumrungrad International Hospital, Bangkok, Thailand, [5]Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA, [6]Department of Infection Biology & Microbiomes, Faculty of Health and Life Sciences, University of Liverpool, Liverpool, UK.



*Corresponding author: Pramote Thangkratok
E-mail: pramot_computer@hotmail.com
Received 14 December 2024 Revised 22 January 2025 Accepted 22 January 2025
ORCID ID: http://orcid.org/0000-0001-8169-411X
https://doi.org/10.33192/smj.v77i6.272715

ABSTRACT

Objective: This study compares the effectiveness of transpore tape and transparent film dressing on the incidence of early-stage phlebitis among patients with peripheral venous catheters.

Materials and Methods: We conducted a randomized controlled prospective study on 308 inpatients in the internal medicine wards of a community hospital in Thailand, from November 2020 to March 2021. The visual infusion phlebitis scale was employed for assessments by registered nurses at least every eight hours.

Results: Demographic and health factors were similar in both transpore tape and transparent film dressing groups. Notably, early-stage phlebitis was detected in 77.92% of patients in the transpore tape group, significantly higher than the 66.88% in the transparent film group (p=0.030). The group using transpore tape had a 1.16 times higher risk of early-stage phlebitis than the group using transparent film dressing (RR = 1.16, 95% CI = 0.116-0.452). Statistical analysis showed a significant difference in catheter removal time between the two groups.

Conclusion: Transparent film dressings demonstrated greater efficacy in reducing early-stage phlebitis incidences in patients with peripheral venous catheters, suggesting their preferable use in clinical settings.

Keywords: Peripheral venous catheter; transparent film dressing; transpore tape; phlebitis (Siriraj Med J 2025; 77: 411-418)

INTRODUCTION

Peripheral intravenous catheters (PIVCs) are a standard invasive nursing procedure used for administering fluids, medications, and blood components.[1] In the United States alone, annual usage ranges between 200 to 300 million,[2] and global estimates indicate approximately 2 billion catheters are utilized annually.[3] A substantial proportion, between 50% to 90%, of hospitalized patients undergo catheter implantation. Despite its necessity, this procedure can lead to complications such as phlebitis.

Phlebitis, the inflammation of veins, can result from the chemical properties of administered substances or bacterial infection.[3-5] The reported incidences of phlebitis range between 0.1% and 63.3%, with symptoms including fever, redness, swelling, pain, localized warmth or coldness, pus formation, and more severe complications like reduced fluid flow, visible vein tracks, tissue damage, organ dysfunction, and blood clots.[6-8] The choice of cannula insertion practices, including the selection of appropriate devices and dressings, is critical in preventing phlebitis.[9] Previous studies have shown divergent outcomes regarding the effectiveness of different dressing types, with some suggesting that transparent film dressings could reduce complications,[10] while others indicate no significant difference or even superiority of gauze and tape dressings.[11,12] To the best of our knowledge, there is no evidence indicating a direct association between the use of transpore tape or transparent film dressing and the incidence of phlebitis. However, further investigation is necessary to confirm this finding.

Given the conflicting evidence and the absence of specific data comparing transpore tape and transparent film dressing in early phlebitis, this study aims to bridge this gap. Additionally, considering the varied costs of these dressings, a comprehensive cost-effectiveness analysis is essential.[13] This study seeks to evaluate the efficacy of transpore tape and transparent film dressing on the incidence of early-stage phlebitis in patients with peripheral venous catheters, potentially offering new insights and strategies for early management of the phlebitis.

MATERIALS AND METHODS

Study design

This study was a randomized controlled trial with a parallel-group design, conducted on inpatients in the internal medicine wards of a community hospital in Thailand. The trial spanned from November 2020 to March 2021.

Ethical considerations

All participants provided written informed consent. The study received ethical approval from the Institutional Review Board of the Faculty of Medicine, Chulalongkorn University (COA No.1037/2020, IRB No.332/63) on August 27, 2020. The trial was officially registered in the Thai Clinical Trial Registry (TCTR20210801004).

Participants

The study included adult patients over the age of 18 years who underwent IV therapy with osmolality less than 820 mOsm/L via a PIVC during their hospital stay. Participants were required to have a body mass index (BMI) ranging from 18.50 to 22.90 kg/m^2 and be

communicative, cooperative, and willing to engage in the study. The study excluded patients on immunosuppressive therapy, those with hypercoagulability disorders, patients experiencing diaphoresis, those with peripheral nervous system disorders, or a known allergy to transparent dressings.

Randomization

Participants were divided into two groups through block randomization, utilizing blocks of two based on a table of random numbers. The groups were 1) the transpore tape dressing group, and 2) the transparent film dressing group. Enrollment and assignment of participants to each group were conducted by a registered nurse (RN). Participants could not be blinded to the intervention due to the nature of the dressing types, as they were able to visibly identify the type of dressing applied.

Interventions

The PIVCs were administered by an RN to patients meeting the inclusion criteria. To minimize the risk of phlebitis, the smallest gauge and shortest length PIVC compatible with the prescribed therapy were selected.[14] Preferred sites for catheter insertion included the basilic, cephalic, dorsal metacarpal, and dorsal venous arch veins on the dorsal forearm.[14,15]

The PIVC insertion followed a strict aseptic protocol. This process began with routine hand hygiene, a practice repeated as necessary, especially after handling any invasive medical devices.[14] Skin preparation for catheter insertion involved using a 70% alcohol solution for antiseptic purposes.[16] After PIVC insertion, a separate RN, who was not involved in the initial procedure, applied the dressing. In the transpore tape group, a transpore tape was used to secure the catheter.

Outcome measures

The primary outcome of this study was the incidence of early-stage phlebitis, assessed using the Visual Infusion Phlebitis Scale. Post-insertion of the catheter, an RN conducted evaluations at least every eight hours. The outcome assessment was performed by an independent registered nurse (RN). The RN was not involved in the clinical trial procedures or group allocation, ensuring that the assessment of phlebitis outcomes was unbiased. The phlebitis grading at the insertion site was independently reviewed by two researchers, who then collaborated to reach a consensus on the visual infusion phlebitis score. Early-stage phlebitis was defined as a level 2 on a scale ranging from 0 to 5, where 0 represents no signs of phlebitis and 5 indicates an advanced stage, characterized by the presence of two or more symptoms such as pain, erythema, or swelling.[17]

Sample size calculation

The sample size for this non-inferiority or superiority trial was calculated using a specific statistical formula. This calculation resulted in a requirement of 138 participants per group. To accommodate potential dropouts and other unforeseen contingencies, an additional 10% was factored in, bringing the total to 308 patients. Consequently, the study included 154 patients in the transpore tape dressing group and 154 in the transparent film dressing group, each with attached peripheral venous catheters.

Statistical analysis

The data were analyzed using the Statistical Package for Social Sciences (SPSS) version 23.0 for Windows. This included descriptive statistics, chi-square tests, and Fisher's exact test. Fisher's exact test was used to analyze categorical data because it is particularly appropriate when sample sizes are small or when the expected frequencies in any of the cells of a contingency table are below 5. In our study, certain subgroups had relatively small frequencies, which could have violated the assumptions of the Chi-square test (i.e., expected frequencies should be at least 5 in each cell). As a result, Fisher's exact test was chosen because it is more reliable for determining the significance of associations in these cases, without the risk of invalid conclusions due to small sample sizes. We performed a multivariable analysis to control for potential confounding factors that could influence the comparison of the two interventions. This analysis allowed us to adjust for relevant determinants, such as patient characteristics (e.g., age, gender, comorbidities) and baseline conditions that could impact the outcomes related to early state of phlebitis. Relative risk (RR) was calculated using SPSS 23.0. The threshold for statistical significance was set at a p-value of less than 0.05. The relative risk (RR), or risk ratio, is the ratio of the risk of an event in the transpore tape dressing group (e.g., exposed group) versus the risk of the event in the transparent film dressing group (e.g., nonexposed group) and the confidence interval (CI). A p-value of less than 0.05 in this analysis indicated a statistically significant association between the groups. In addition to the intention-to-treat (ITT) analysis, a per-protocol analysis was conducted as a secondary approach. The per-protocol analysis included only those participants who adhered strictly to the assigned intervention protocol and completed the study as per the predefined procedures. This analysis was performed to assess the outcomes based on the

participants who followed the treatment plan without any deviations.

RESULTS

Participant characteristics

Between November 2020 and March 2021, 1,219 adult inpatients from the internal medicine wards of a Community Hospital were evaluated for eligibility. Of these, 403 were excluded due to IV therapy with osmolality <820 mOsm/L via PIVC and having a BMI below 18.5 or above 22.90 kg/m^2. Additionally, 508 chose not to participate. Consequently, 308 adult patients were recruited and evenly divided into two groups of 154 each (Fig 1).

Table 1 reveals that both transpore tape dressing group and the transparent film dressing group were comparable in terms of gender, average age, highest level of education, presence or absence of chronic diseases, smoking habits, number of insertion attempts, PIVC site, use of IV medication, and IV fluid utilization. No significant differences were observed between the two groups.

Table 2 presents the incidence of early-stage phlebitis between the groups. The transpore tape dressing group exhibited a 77.92% incidence, while the transparent film dressing group showed a 66.88%. A statistically significant difference in phlebitis incidence between the groups was observed. The group using transpore tape had a 1.16 times higher risk of early-stage phlebitis than the group using transparent film dressing (RR = 1.16, 95% CI = 0.116-0.452).

Table 3 shows the comparison of data for catheter dwell time. In this table, 53.25% of catheters in the transpore tape dressing group had a catheter dwell time of 49–72 h, whereas 61.69% of catheters in the transparent film dressing group had a dwell time of 73-96 h. The analysis showed that catheter dwell time of 49–72 h and 73-96 h varied by the groups, which was statistically significant ($p < 0.001$)

DISCUSSION

Peripheral Intravenous Catheter (PIVC) administration, globally used to deliver fluids, medications, or blood components, frequently results in phlebitis due to the procedure's invasive nature. Therefore, ensuring the catheter's stability is vital to reduce complications. This research compared the effectiveness of transpore tape and transparent film dressing on the incidence of early-stage phlebitis in patients with a PIVC. We found that early-stage phlebitis developed in 77.92% of the transpore tape group, in contrast to 66.88% in the transparent film dressing group. A statistically significant difference in the

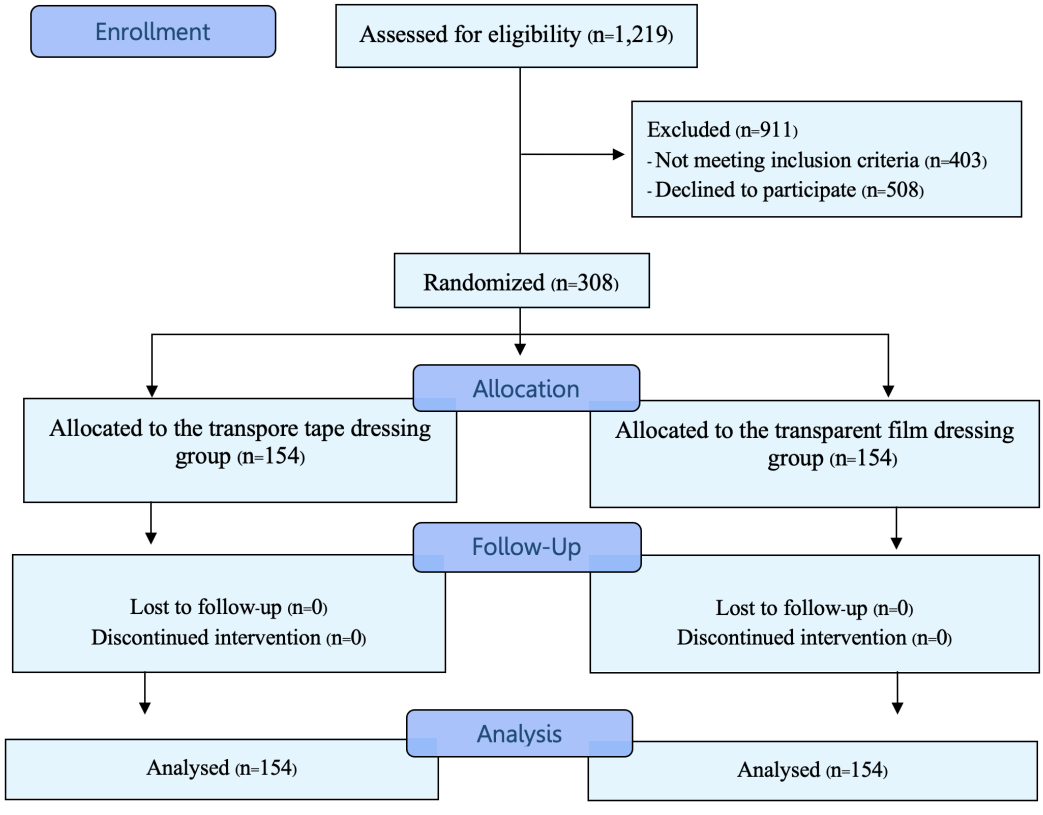


Fig 1. CONSORT 2010 flow diagram of the clinical trial.

TABLE 1. Participants characteristics.

Individuals' characteristics	The transpore tape dressing group (n=154)		The transparent film dressing group (n=154)		Statistical significance
	N	%	N	%	
Gender					x^2 = 0.468, p = 0.494
Female	82	53.25	76	49.35	
Male	72	46.75	78	50.65	
Age	**Mean ± SD**		**Mean ± SD**		t = -0.123, p = 0.902
	57.57 ± 18.34		57.84 ±19.53		
Highest educational					x^2 = 2.399, p = 0.310
Primary School	5	3.25	8	5.19	
Secondary School	133	86.36	123	79.87	
Bachelor Degrees	16	10.39	23	14.94	
Having a chronic disease					x^2 = 2.561, p = 0.110
Yes	111	72.08	123	79.87	
No	43	27.92	31	20.13	
Use of Smoking					x^2 = 0.120, p = 0.729
Using	20	12.99	18	11.69	
Not in use	134	87.01	136	88.31	
Number of attempt					x^2 = 0.151, p = 0.698
1 time	42	27.27	39	25.32	
> 1 time	112	72.73	115	74.68	
The site of PIVC					x^2 = 5.956, p = 0.114
Basilic vein	15	9.74	29	18.83	
Cephalic vein	101	65.58	91	59.09	
Dorsal metacarpal veins	34	22.08	28	18.18	
Dorsal venous arch	4	2.60	6	3.90	
Use of IV medication					x^2 = 0.024, p = 0.876
Using	130	84.42	129	83.77	
Not in use	24	15.58	25	16.23	
Use of IV fluid					x^2 = 1.903, p = 0.168
Using	124	80.52	133	86.36	
Not in use	30	19.48	21	13.64	

TABLE 2. Comparison of data for early state of phlebitis.

The early state of phlebitis	The transpore tape dressing group (n=154)		The transparent film dressing group (n=154)		Statistical significance
	N	%	N	%	
Yes	120	77.92	103	66.88	$x^2 = 4.696$, $p = 0.030$
No	34	22.08	51	33.12	
Total	**154**	**100.00**	**154**	**100.00**	

TABLE 3. Comparison of data for catheter dwell time.

Catheter dwell time	The transpore tape dressing group (n=154)		The transparent film dressing group (n=154)		Statistical significance
	N	%	N	%	
24–48 h	1	0.65	3	1.95	*p = < 0.001*
49–72 h	82	53.25	5	3.25	*Fisher's Exact Test*
73-96 h	37	24.03	95	61.69	

incidence of phlebitis was observed between the groups.[18] Despite these variations, both investigations underscore a significant difference in complication rates between the groups. Transparent film dressing is an adhesive dressing made of thin, transparent film placed over the PIVC. It is designed to be breathable and waterproof, allowing for easy wound monitoring without needing to remove the dressing. Transpore tape, on the other hand, is a perforated medical tape with strong adhesive properties, making it ideal for securing thicker dressings and tubing. It is hypoallergenic, latex-free, and customizable in width, often used for covering PIVC.[10,19]

Our results align with previous studies,[10,19] which advocate for the use of transparent film dressings in PIVC applications due to fewer complications. The consistency across these studies suggests that the enhanced catheter stabilization capabilities of transparent film dressings play a pivotal role in reducing the incidence of phlebitis. Transparent film dressings act as a protective barrier against external contaminants and pathogens, reducing the need for frequent dressing changes, thereby preserving skin integrity and minimizing the risk of infection.[12,20-24] The ease of use associated with these dressings reduces complications such as skin damage from repeated changes, leading to reduced pain and lower infection probabilities.[10,19,25] The study results revealed a statistically significant difference between the group that received the transparent film dressing and the group that received the transpore tape. This suggests that the transparent film dressing was more effective in securing PIVC than the transpore tape. It is important to note that the study was conducted under controlled conditions and may not necessarily reflect real-world scenarios.

In the study comparing catheter dwell times between the transpore tape dressing group and the transparent film dressing group, it was found that 53.25% of catheters in the transpore tape dressing group had a dwell time of 49–72 hours, while 61.69% of catheters in the transparent film dressing group had a dwell time of 73-96 hours. The analysis revealed a statistically significant variation in catheter dwell times between the two groups. This discrepancy in dwell times suggests that the type of dressing used has an impact on how long catheters remain in place. Specifically, a higher percentage of catheters in the transparent film dressing group had a longer

dwell time of 73-96 hours compared to the transpore tape dressing group, where more catheters had a dwell time of 49–72 hours. The statistical significance of this difference indicates that it is unlikely to have occurred by chance alone. It may be attributed to the properties of the dressings and their influence on catheter stability and adhesion.[26,27]

These findings have implications for clinical practice and may inform decisions regarding the selection of dressing types for catheter securement. Healthcare providers should consider the potential impact of dressings on catheter dwell times when making choices about patient care. Additionally, these results contribute to the body of knowledge in catheter-related research and may guide future studies investigating optimal catheter management strategies. One limitation of our research was its limited scope, involving a small participant pool from a single hospital clinic. Future studies should expand the sample size and encompass multiple settings for a more comprehensive analysis.

CONCLUSION

The early-stage phlebitis incidence was 77.92% in the transpore tape dressing group and 66.88% in the transparent film dressing group. This difference was statistically significant, suggesting transparent film dressing may reduce phlebitis occurrence when attaching peripheral venous catheters. The study compared catheter dwell times between two groups, one using transpore tape dressing and the other using transparent film dressing. Statistical analysis demonstrated a significant difference in catheter dwell times between the two groups, suggesting that the type of dressing used influences how long catheters stay in place.

Data Availability Statement

The data supporting this study are available from the corresponding author upon reasonable request.

ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to all participants for their time and cooperation in this study. Your kindness and commitment have been invaluable to the success of this research.

DECLARATION

Grants and Funding Information

None.

Conflict of Interest

All authors declare no conflicts of interest.

Registration Number of Clinical Trial

The trial was officially registered in the Thai Clinical Trial Registry (TCTR20210801004).

Author Contributions

Conceptualization and methodology, P.T and K.P. ; Investigation, P.M., K.P., J.S. ; Formal analysis, P.T. and K.P. ; Visualization and writing – original draft, P.T. ; Writing – review and editing, P.T., K.P., J.S. ; Supervision, P.T. All authors have read and agreed to the final version of the manuscript.

Use of Artificial Intelligence

Not applicable.

REFERENCES

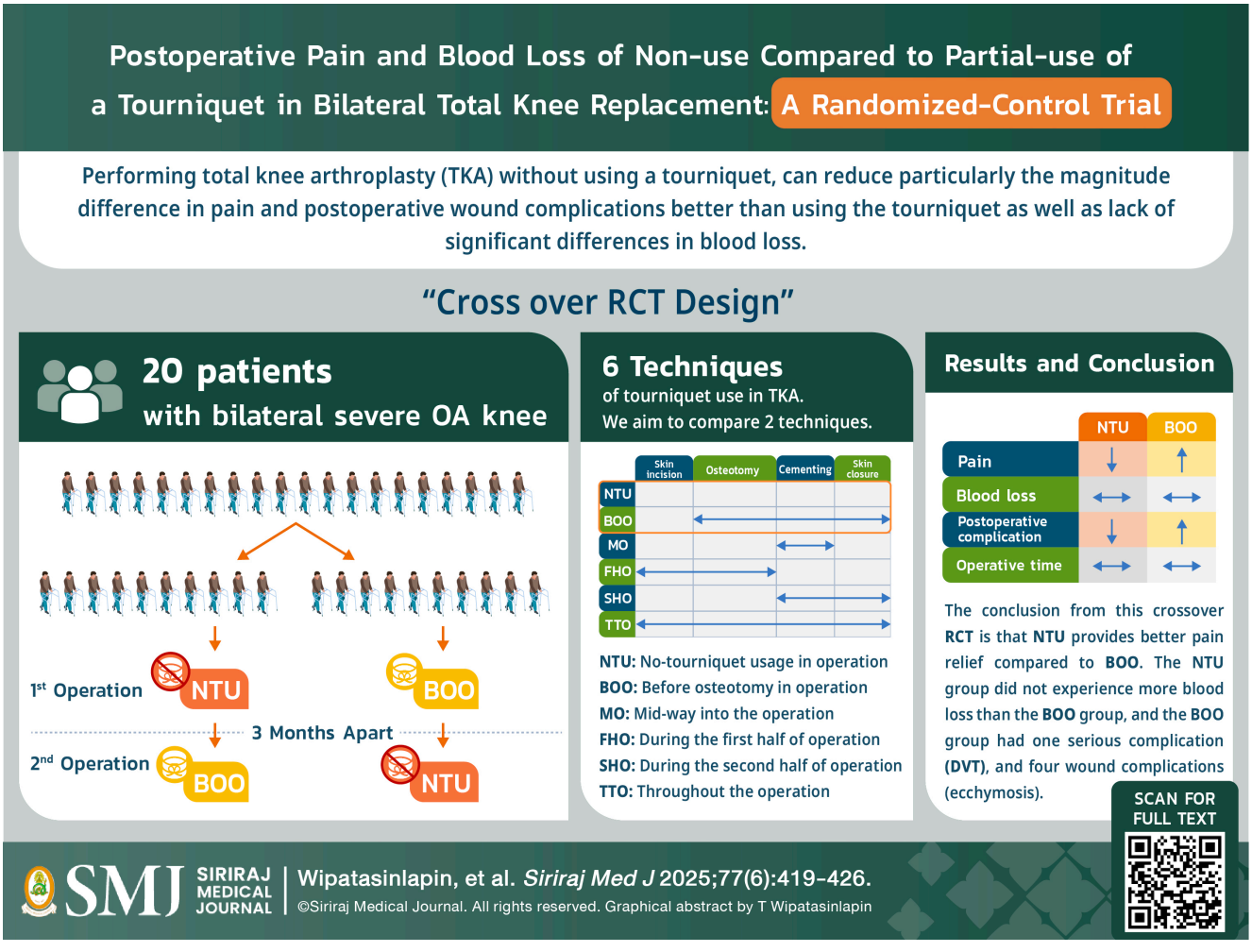
1. Makafi S, Marfega M. Peripheral intravenous catheter (PIVC) related local complications among patients in KFCH-Jizan. Adv Practice Nurs. 2017;2(3).
2. Maki DG. Improving the safety of peripheral intravenous catheters. BMJ. 2008;337(7662):a630.
3. Zingg W, Pittet D. Peripheral venous catheters: an under-evaluated problem. Int J Antimicrob Agents. 2009;34 Suppl 4:S38-42.
4. Campbell L. IV-related phlebitis, complications and length of hospital stay: 1. Br J Nurs. 1998;7(21):1304-12.
5. Collin J, Constable F, Collin C, Johnston I. Infusion thrombophlebitis and infection with various cannulas. Lancet. 1975;306(7926):150-3.
6. Laudenbach N, Carie AB, Klaverkamp L, Hedman-Dennis S. Peripheral IV stabilization and the rate of complications in children: an exploratory study. J Pediatr Nurs. 2014;29(4):348-53.
7. Helm RE, Klausner JD, Klemperer JD, Flint LM, Huang E. Accepted but unacceptable: peripheral IV catheter failure. J Infus Nurs. 2015;38(3):189-203.
8. Enes SM, Opitz SP, Faro AR, Pedreira Mde L. Phlebitis associated with peripheral intravenous catheters in adults admitted to hospital in the Western Brazilian Amazon. Rev Esc Enferm USP. 2016;50(2):263-71.
9. Higginson R, Parry A. Phlebitis: treatment, care and prevention. Nurs Times. 2011;107(36):18-21.
10. Atay S, Yilmaz Kurt F. Effectiveness of transparent film dressing for peripheral intravenous catheter. J Vasc Access. 2021;22(1):135-40.
11. Forni C, Loro L, Tremosini M, Trofa C, D'Alessandro F, Sabattini T, et al. Effectiveness of sterile transparent dressing than the standard for attaching peripheral venous catheter (CVP) on the incidence of phlebitis: randomized controlled trial. Assist Inferm Ric. 2012;31(2):63-9.
12. Bausone-Gazda D, Lefaiver CA, Walters SA. A randomized controlled trial to compare the complications of 2 peripheral intravenous catheter-stabilization systems. J Infus Nurs. 2010;33(6):371-84.
13. Marsh N, Webster J, Mihala G, Rickard CM. Devices and dressings to secure peripheral venous catheters to prevent complications. Cochrane Database Syst Rev. 2015;(6):CD011070.

14. Gorski LA, Hadaway L, Hagle ME, Broadhurst D, Clare S, Kleidon T, et al. Infusion therapy standards of practice. J Infus Nurs. 2021;44(1S Suppl 1):S1-S224.
15. Alexandrou E, Ray-Barruel G, Carr PJ, Frost SA, Inwood S, Higgins N, et al. Use of short peripheral intravenous catheters: characteristics, management, and outcomes worldwide. J Hosp Med. 2018;13(5).
16. Boyce JM. Best products for skin antisepsis. Am J Infect Control. 2019;47(S):A17-A22.
17. Doesburg F, Smit JM, Paans W, Onrust M, Nijsten MW, Dieperink W. Use of infrared thermography in the detection of superficial phlebitis in adult intensive care unit patients: a prospective single-center observational study. PLoS One. 2019;14(3):e0213754.
18. Atay S, Sen S, Cukurlu D. Phlebitis-related peripheral venous catheterization and the associated risk factors. Niger J Clin Pract. 2018;21(7):827-31.
19. Gabriel J. Vascular access devices: securement and dressings. Nurs Stand. 2010;24(52):41-6.
20. Bernatchez SF. Care of peripheral venous catheter sites: advantages of transparent film dressings over tape and gauze. J Assoc Vasc Access. 2014;19(4):256-61.
21. De Bono S, Heling G, Borg MA. Organizational culture and its implications for infection prevention and control in healthcare institutions. J Hosp Infect. 2014;86(1):1-6.
22. Ezzelarab MH, Nouh O, Ahmed AN, Anany MG, Rachidi NGE, Salem AS. A randomized control trial comparing transparent film dressings and conventional occlusive dressings for elective surgical procedures. Open Access Maced J Med Sci. 2019;7(17):2844-50.
23. Chunhasuwankul R, Owattanapanich N, Somcharit L, Pantheepo H, Prasanrat S, Yiengpruksawan A. A prospective randomized controlled trial comparing infection rates of the daily dressing and scheduled dressing of sutured traumatic wounds. Siriraj Med J. 2018;70(5):377-81.
24. Loveday HP, Wilson JA, Pratt RJ, Golsorkhi M, Tingle A, Bak A, et al. epic3: National evidence-based guidelines for preventing healthcare-associated infections in NHS hospitals in England. J Hosp Infect. 2014;86(S1-S70).
25. Özkula U, Özhasenekler A, Kurtoğlu Çelik G, Tanrıverdi F, Pamukçu Günaydın G, Ergin M, et al. Tissue adhesives to secure peripheral intravenous catheters: a randomized controlled trial in patients over 65 years. Turk J Emerg Med. 2019;19(1):12-5.
26. Corley A, Marsh N, Ullman AJ, Rickard CM. Peripheral intravenous catheter securement: an integrative review of contemporary literature around medical adhesive tapes and supplementary securement products. J Clin Nurs. 2023;32(9-10):1841-57.

Postoperative Pain and Blood Loss of Non-use Compared to Partial-use of a Tourniquet in Bilateral Total Knee Replacement: A Randomized-Controlled Trial

Thada Wipatasinlapin, M.D.[1,*], Surapon Atiprayoon, M.D.[1], Peerawin Atiprayoon[2]

[1]Queen Savang Vadhana Memorial Hospital, Chonburi, Thailand, [2]Triam Udom Suksa School, Bangkok, Thailand.



*Corresponding author: Thada Wipatasinlapin
E-mail: fighter.thada@gmail.com
Received 11 September 2024 Revised 18 February 2025 Accepted 19 February 2025
ORCID ID: http://orcid.org/009-0002-0067-4470
https://doi.org/10.33192/smj.v77i6.271055

ABSTRACT

Objective: This study aimed to compare the effects of non-tourniquet usage (NTU) and partial-tourniquet usage (before osteotomy in operation; BOO) of a tourniquet in bilateral total knee arthroplasty (TKA) on postoperative pain and complications.

Materials and Methods: A prospective randomized controlled trial with cross-over design was designed to compare the effect of NTU vs BOO in the patients underwent bilateral TKA. The opioid consumption and pain score were primary outcomes. Blood loss, the number of wound complications, the postoperative complications and time to ambulation were secondary outcomes.

Results: NTU group showed a significantly reduction in opioid consumption (14.8 ± 8.3 mg) as compared to that of BOO group (24.6 ± 10.8 mg) in the postoperative 24 hours. The postoperative pain score was significantly lower by the first, second, third and fourth day postoperative in NTU group (3.2, 3.9, 3.5, 2.3) compared to BOO group (4.3, 5.6, 4.8, and 4.1). There was no significant difference in blood loss between the groups. Early postoperative wound ecchymosis was found in BOO group (5 knees), more than in the NTU group (1 knee) with statistical significance.

Conclusion: Performing total knee arthroplasty (TKA) without using a tourniquet, can reduce particularly the magnitude difference in pain and opioid consumption better than using the tourniquet as well as lack of significant difference in blood loss. This will allow for future clinical implications to determine that NTU may be preferable due to reduced postoperative pain and fewer postoperative wound complications.

Keywords: Total knee arthroplasty; bilateral; tourniquet; pain (Siriraj Med J 2025; 77: 419-426)

INTRODUCTION

Currently, total knee arthroplasty (TKA) has become increasingly common, due to its efficacy to improve patients' quality of life and reduce pain[1] allowing those patients with knee osteoarthritis who failed conservative treatment, to regain their ability to walk normally again. In TKA surgeries, the use of a tourniquet has been employed to aid in the reduction of blood loss during the procedure, and improving intraoperative visualization for the operating surgeon.[2-4]

However, the use of a tourniquet in TKA surgeries remains a topic of debate. There are research studies supporting its use, and some supporting operations without using a tourniquet.[5,6] While TKA with a tourniquet may reduce the operating time, it has been found to be associated with more complications. These complications include deep vein thrombosis, and an increase in occurrences of surgical-site infection, or bruising with signs of bleeding.[7] Moreover, several research studies have also found that patients - in the group using a tourniquet - experience more postoperative pain.[8] This is believed to be due to the tourniquet causing metabolic waste to accumulate in the thigh muscles, and in blood vessels around the area where it is applied.[2]

Latest evidence suggests that the most debating tourniquet-use technique is between NTU (Non-tourniquet usage) and BOO (Before Osteotomy in Operation), which involves using a tourniquet before starting the bone cutting, until wound closure. Despite numerous meta-analyses, and randomized-control trials (RCTs), there is still no conclusive evidence on the most effective, and efficient method of using a tourniquet especially between these two techniques.[9] This is because the data come from various experimental designs, with most of previous research data, being captured from studies of the outcomes of tourniquet usage in unilateral total knee arthroplasty. Hence, these studies often lack a crossover design, which could introduce confounding variables. Therefore, we designed a protocol which was a randomized-control trial with a crossover design, specifically studying the outcomes of tourniquet use in the bilateral total-knee arthroplasty of each limb in the same patient, aiming to provide clearer insights into the benefits of different tourniquet techniques.

MATERIALS AND METHODS

Inclusion and exclusion criteria

Patients diagnosed with bilateral severe knee osteoarthritis, meeting the inclusion criteria, were recruited at our institution from November 2022 to August 2024. We obtained an approval from the Institutional Review Board (IRB) of the Queen Savang Vadhana Memorial Hospital. This trial had been registered in clinical trial registry before participant enrollment (NCT06815445). The inclusion criteria were patients diagnosed with bilateral severe knee osteoarthritis, over 50 years of age. The exclusion criteria were patients having undergone previous knee surgery, being subject to uncontrolled

hypertension, coagulopathy, or recent knee sepsis, with an ASA physical status grade > 2, inability to use patient-controlled analgesia (PCA), such as communication, or cognitive issues, or those patients who were allergic to medications used in the treatment process.

Patients

20 patients (40 knees) were randomized into two groups with an allocation ratio of 1:1, determined by the various block randomization method employing a computer-generated program. Ten patients underwent NTU in the first operation and BOO in 3 months later. On the other hand, ten patients underwent BOO in the first operation and NTU in 3 months later. The two operations were spaced more than 3 months apart, as previous research indicates that this can significantly reduce morbidity and mortality, particularly concerning cardiovascular risk.[10]

On the day of the surgery, the orthopedic resident conducted the sampling method by opening a sealed envelope before the operation to determine which patients would undergo surgery without the use of a tourniquet (NTU) and which patients would have partial use of a tourniquet (BOO). Communication in the operating room would be taken place in the patient waiting area to prevent patients hearing the method of tourniquet use during that time.

Surgical technique and postoperative evaluation

The operations were performed by a single surgeon, an experienced orthopedic surgeon sub-specializing in knee arthroplasty. The surgeries involved several steps. Firstly, performance of spinal anesthesia, was carried out by an anesthesiologist. Next, was the application of an appropriately-sized, and positioned tourniquet to the patient's thigh. Then, prophylactic antibiotics were administered intravenously, being given 30 minutes prior to surgery. This was followed by the intravenous administration of ketorolac, 30 mg and Tranexamic acid 1 g, being given 30 minutes before the skin incision was made. The surgeon made a midline incision on the skin, adopting a sub-vastus approach, using an intramedullary guide wire for femur, and extramedullary guide wire for the tibia cuts. A cemented prosthesis of Zimmer Nextgen was used – as it was in every operation. A tourniquet was inflated to the systolic blood pressure (SBP), plus 100 mmHg in the leg of patients undergoing partial-use of a tourniquet (BOO), at the time of the start of the bone osteotomy until skin closure. Finally, a compressive dressing was applied, and covered with a Robert Jones bandage.

The postoperative care included an adductor canal block, with 0.25% Marcaine 20 ml, applied by an anesthesiologist in the patient recovery room to alleviate knee pain on the side operated on. Prophylactic antibiotics were administered for 48 hours post-surgery. The intravenous pain medication was given through patient-controlled analgesia (PCA), along with opioid drugs as pain relief, for the first 3 days post-surgery. The same oral pain control medications were administered for all patients. A redivac drain was removed on first postoperative day. On the second, and third postoperative days, an occlusive dressing was applied to the wound, and the patient was encouraged to ambulate with a walker.

All postoperative outcomes were performed by a single orthopedic resident. The primary outcome was the presence of postoperative pain, assessed in terms of the amount (mg) of opioid consumption, using the patient-controlled analgesia (PCA) machine at 24, 48, and 72 hours postoperative. The visual analog scale (VAS) score - ranging from 0-10 (0-2 was minimal pain, 2-4 was mild pain, 4-7 was moderate and 7-10 was severe pain) was also obtained at postoperative day 1 to day 3. 3. For the secondary outcomes, blood loss was calculated by comparing the maximal hematocrit drop between preoperative hematocrit levels and the postoperative levels on either the first or the fourth postoperative day. The time to ambulation, complications, including deep vein thrombosis (DVT), wound complications were recorded.

Sample size calculation

Calculated using STATA Version 14.0 with a power of 80% and an alpha of 0.05, the mean (SD) differences were referenced from the study by Kumar et al. (2015), (11) which examined postoperative pain using VAS for pain with different tourniquet methods in patients undergoing knee replacement surgery. This resulted in a total population of 36 knees, divided into 18 knees per group. Factoring in a 10% dropout rate, the total population needed is 40 knees, with 20 knees per group.

RESULTS

The study collected data from patients with bilateral knee osteoarthritis who underwent staged bilateral total knee arthroplasty, with at least a 3-month interval between operations. In the first group of 20 patients, the initial surgery was performed without a tourniquet (NTU), and the second surgery used a partial tourniquet (BOO) applied to the other knee. In the second group of 20 patients, the initial surgery used a partial tourniquet (BOO), while the second surgery to the other knee was

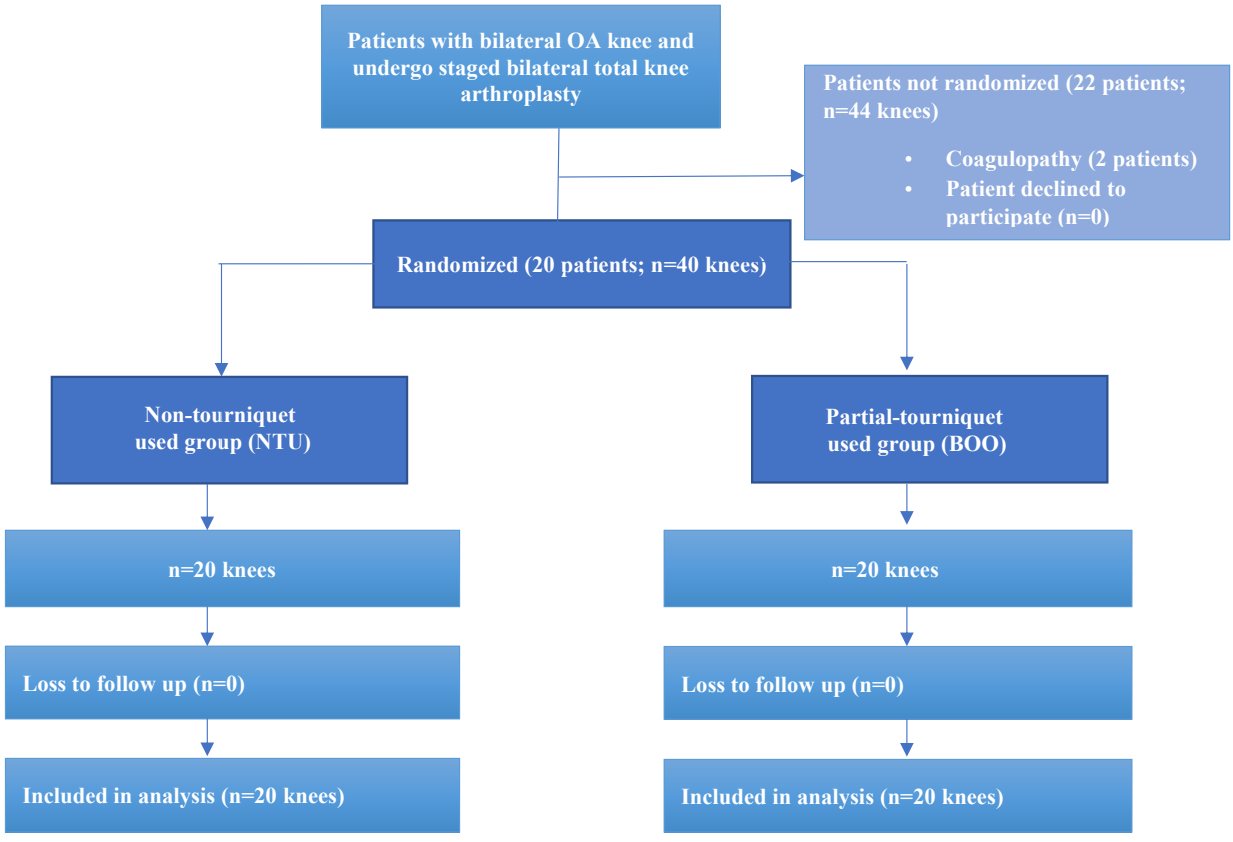


Fig 1. CONSORT Diagram

performed without tourniquet (NTU). Thus, the study analyzed a total of 20 patients (40 knees). (Table 1)

There were no cases of loss to follow-up in the study. There was 1 case with a serious complication, being Deep Vein Thrombosis (DVT) in a knee operated on with BOO with statistically significant difference, and 5 cases of wound complications in BOO group, and 1 case in NTU group with statistical significance.

The primary outcome of interest in this study was the difference in pain levels during the early postoperative period, from day 1 to day 4 before the patients were discharged, assessed in terms of the morphine consumption.

TABLE 1. Baseline characteristics.

Variable	Non-tourniquet used group first (NTU) (10 patients)	Partial-tourniquet used group (BOO) (10 patients)	P-value
Age, yr	74.3 ± 7.1	72.9 ± 8.4	0.6711
Gender; male: female	2:8	1:9	0.6200
Body mass index	27.2 ± 3.4	28.1 ± 4.5	0.6200
Preoperative hematocrit (%)	37.3 ± 3.4	38.9 ± 4.5	0.3815
Tourniquet duration (min) (for the first surgery)	0	45.6 ± 10.4	-
Operating time (for the first surgery)	93.8 ± 10.7	89.3 ± 8.5	0.3115

It was hypothesized that less pain would result in faster recovery, and earlier initiation of physical therapy, as well as greater patient satisfaction.

Results showed that the NTU group had a morphine consumption of 14.8 ± 8.3 mg in the first 24 hours after surgery, while the BOO group had a morphine consumption of 24.6 ± 10.8 mg during the same period. (Fig 2) The NTU group used significantly less morphine in the first 24 hours post-surgery with statistical significance (P value < 0.05). The following day, morphine consumption in the NTU group remained lower as shown in Table 2, but this difference was not statistical significance.

Consistent with these findings, the Visual Analog Scale (VAS) scores showed that the mean VAS score in the NTU group was 3.2, 3.9, 3.5, and 2.3 on postoperative days 1, 2, 3, and 4 respectively. In the BOO group, the mean VAS score was 4.3, 5.6, 4.8, and 4.1 on the same days. (Table 3 and Fig 3) There was a significant difference in pain scores between the NTU and BOO groups on postoperative days 1-4 (P value < 0.05).

No significant differences were found in postoperative blood loss, as assessed by decrease in the maximum hematocrit, between the two groups. (Table 4)

No significant differences were found in time to ambulation between two groups.

DISCUSSION

Until now, based on a recent systematic review, and on a meta-analysis conducted by Cao et al. in 2021, there are six techniques of using a tourniquet in total knee arthroplasty surgery.[9] The objective was to determine which tourniquet technique provides the best outcomes for patients undergoing surgery, and results in reduced postoperative complications, as well as facilitating early postoperative ambulation without pain. These techniques are:

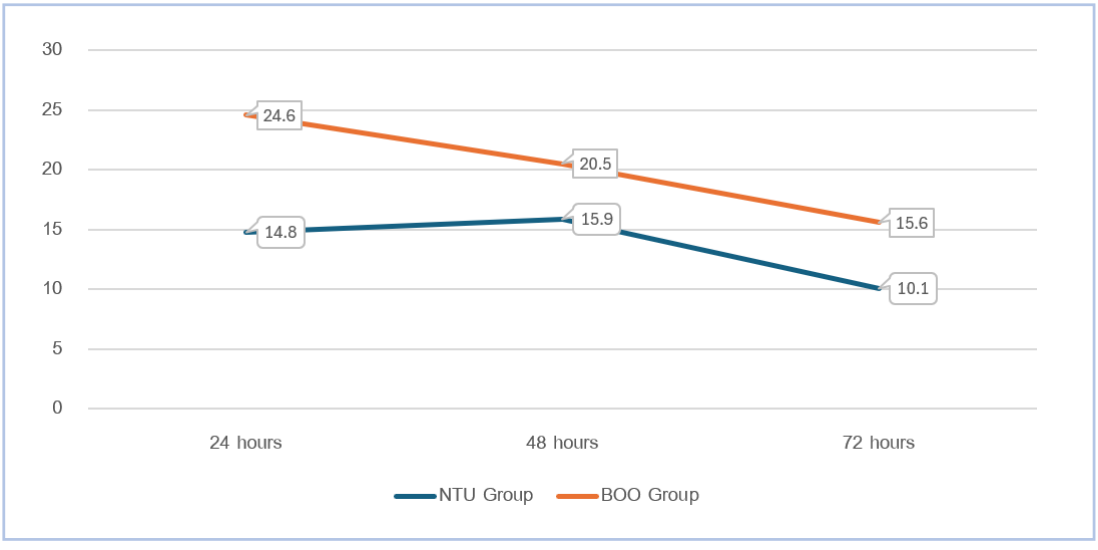


Fig 2. Morphine consumption between groups during hospital stays.

TABLE 2. Comparison of morphine consumption between groups

Time	Non-tourniquet used group (NTU) (n=20)	Partial-tourniquet used group (BOO) (n=20)	t	P (two-tailed)	Effect size (Cohen's d)
24 hours	14.8 ± 8.3	24.6 ± 10.8	3.2176	0.0026*	1.017
48 hours	15.9 ± 10.8	20.5 ± 9.6	1.4237	0.1627	0.450
72 hours	10.1 ± 5.5	15.6 ± 10.9	2.0146	0.0511	0.637

TABLE 3. Comparison of VAS for pain between groups.

Time	Non-tourniquet used group (NTU) (n=20)	Partial-tourniquet used group (BOO) (n=20)	t	P (two-tailed)	Effect size (Cohen's d)
POD 1	3.2 ± 1.8	4.3 ± 1.6	2.0426	0.0481*	0.645
POD 2	3.9 ± 1.5	5.6 ± 1.1	4.0872	0.0002*	1.292
POD 3	3.5 ± 1.6	4.8 ± 1.2	2.9069	0.0061*	0.919
POD 4	2.3 ± 1.1	4.1 ± 1.1	5.1746	0.0001*	1.636

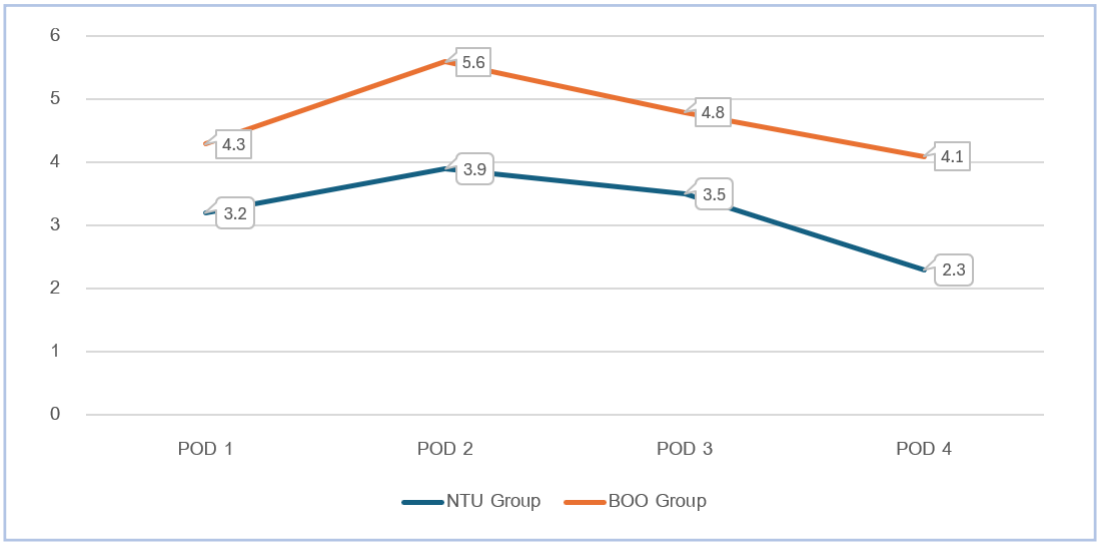


Fig 3. VAS for pain between groups during hospital stays

TABLE 4. Comparison of blood loss between groups.

Time	Non-tourniquet used group (NTU) (n=20)	Partial-tourniquet used group (BOO) (n=20)	t	P (two-tailed)	Effect size (Cohen's d)
Preop	37.3 ± 3.4	38.9 ± 4.5	1.4030	0.1687	0.401
POD 1	32.7 ± 4.1	34.4 ± 3.3	1.6172	0.1141	0.456
POD 4	31.8 ± 3.2	32.8 ± 2.5	1.1013	0.2777	0.348
Maximum drop	7.2 ± 2.3	6.9 ± 3.3	0.3335	0.7406	0.105

1) Non-tourniquet usage (NTU): No tourniquet is used throughout the surgery.
2) Mid-way into the operation (MO): Tourniquet is used only during the period of cement implantation.
3) During the first half of operation (FHO): Tourniquet is used from skin incision until bone osteotomy is finished.
4) During the second half of operation (SHO): Tourniquet is used from cement implantation until wound closure is finished.
5) Before osteotomy in operation (BOO): Tourniquet is used from bone osteotomy until wound closure is finished.
6) Throughout the operation (TTO): Tourniquet is used from skin incision until wound closure is finished.

This recent systematic review and meta-analysis suggests that the best recommended technique is BOO (Before Osteotomy in Operation), which involves using a tourniquet before starting the bone cutting, until wound closure. This technique has been found to be the most effective in reducing blood loss, shortening the duration of surgery, and minimizing postoperative complications, based on comparative analysis.[9]

Despite the numerous meta-analyses and randomized-control trials (RCTs) conducted, a definitive conclusion on the most beneficial and effective use of tourniquets remains inconclusive.[9,12-14] This is because the available data comes from studies with various methodologies, including many that have focused on the effect of tourniquets in unilateral total knee arthroplasty (TKA), rather than crossover studies. Such studies may be prone to confounding factors. Therefore, to better understand the benefits, research needs to be conducted using randomized-control trials with a crossover design, specifically examining the effect of tourniquets in patients undergoing bilateral total knee arthroplasty (TKA).

Currently, there are only three RCTs that have studied the effect of tourniquets in bilateral TKA. In 2015, Kumar et al. compared NTU with TTO, and found that patients in the NTU group experienced significantly less postoperative pain compared to those in the TTO group.[11] Then, in 2016, Wang et al. compared FHO with MO, and found that the MO group had significantly less postoperative pain and blood loss compared to the FHO group, leading to better recovery, and physical therapy outcomes.[3] Most recently, in 2017, Liu et al. conducted another study comparing NTU with TTO, and again found that the NTU group had experienced significantly less postoperative pain compared to the TTO group.[8]

However, none of these studies have compared NTU with BOO to determine which method is more effective, and has better outcomes. This is the rationale for the current study, which aims to compare non-use of the tourniquet (NTU) with partial use of the tourniquet (BOO) in the context of bilateral TKA performed on the same patient with at least a 3-month interval between surgeries.

Therefore, the conclusion from this crossover RCT is that NTU provides better pain relief compared to BOO. The NTU group did not experience more blood loss than the BOO group, and the BOO group had one serious complication (DVT), and four wound complications (ecchymosis). Thus, this study supports that performing total knee arthroplasty without a tourniquet is more effective than other methods. The strength of this research lies in its use of a crossover RCT design to minimize confounding factors, and in its objective measurement of pain through morphine consumption, in milligrams.

A limitation of this study is the sample size, which could be increased. Future research could focus on comparing the most effective tourniquet methods by conducting crossover design studies in bilateral total knee arthroplasty. Another limitation was the crossover design itself, the study might have inherent risks of carry-over effects, especially related to differences in recovery post-first surgery that could influence the outcomes of the second surgery.

CONCLUSION

Performing total knee arthroplasty (TKA) without using a tourniquet, can reduce particularly the magnitude of the difference in pain and opioid consumption better than using the tourniquet as well as lack of significant differences in blood loss. This will allow for future clinical implications to determine that NTU may be preferable due to reduced postoperative pain and fewer postoperative wound complications.

Data Availability Statement

Data are available on reasonable request. Data may be obtained from a third party and are not publicly available. Data are available upon request to the authors.

ACKNOWLEDGEMENTS

I would like to thank Queen Savang Vadhana Memorial Hospital Institute for providing the necessary resources and funding for this project. Special thanks to my colleagues, Varissara Chatyanan and Chalathorn Kulthonchalanan, for their assistance with data collection and analysis.

DECLARATIONS

Grants and Funding Information

Queen Savang Vadhana Memorial Hospital Institute

Conflict of Interest

The authors declare no conflicts of interest.

Registration Number of Clinical Trial

NCT06815445

Author Contributions

Conceptualization and methodology, T.W., and S.A. ; Investigation, T.W. ; Formal analysis, T.W., and P.A.; Visualization and writing – original draft, T.W. ; Writing – review and editing, T.W., and S.A. ; Funding acquisition, T.W., and S.A. ; Supervision, S.A. All authors have read and agreed to the final version of the manuscript.

Use of Artificial Intelligence

Not applicable .

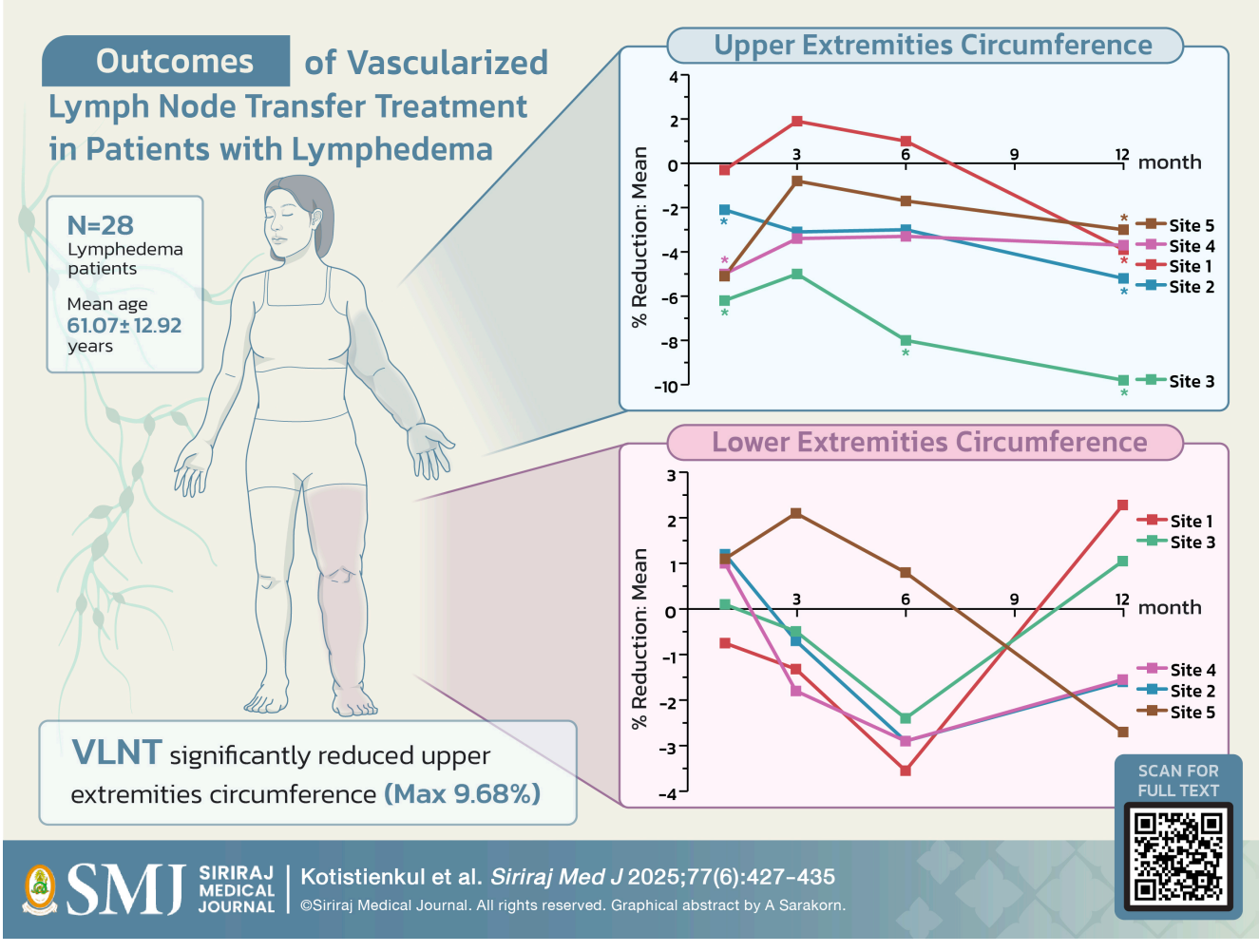
REFERENCES

1. Luansritisakul C. Quality of Life after Total Knee Replacement at Siriraj Hospital, Thailand. Siriraj Med J. 2016;68(2):72-78.
2. Vandenbussche E, Duranthon LD, Couturier M, Pidhorz L, Augereau B. The effect of tourniquet use in total knee arthroplasty. Int Orthop. 2002;26(5):306-9.
3. Ozkunt O, Sariyilmaz K, Gemalmaz HC, Dikici F. The effect of tourniquet usage on cement penetration in total knee arthroplasty: a prospective randomized study of 3 methods. Medicine (Baltimore). 2018;97(4):e9668.
4. Arthur JR, Spangehl MJ. Tourniquet use in total knee arthroplasty. J Knee Surg. 2019;32(08):719-29.
5. Alexandersson M, Wang EY, Eriksson S. A small difference in recovery between total knee arthroplasty with and without tourniquet use the first 3 months after surgery: a randomized controlled study. Knee Surg Sports Traumatol Arthrosc. 2019; 27(4):1035-42.
6. Jawhar A, Stetzelberger V, Kollowa K, Obertacke U. Tourniquet application does not affect the periprosthetic bone cement penetration in total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2019;27:2071-81.
7. Matar HE, Platt SR, Gollish JD, Cameron HU. Overview of randomized controlled trials in total knee arthroplasty (47,675 patients): what have we learnt? J Arthroplasty. 2020;35(6):1729-36.e1.
8. Liu Y, Si H, Zeng Y, Li M, Xie H, Shen B. More pain and slower functional recovery when a tourniquet is used during total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2020;28: 1842-60.
9. Cao Z, Guo J, Li Q, Wu J, Li Y. Comparison of efficacy and safety of different tourniquet applications in total knee arthroplasty: a network meta-analysis of randomized controlled trials. Ann Med. 2021;53(1):1816-26.
10. Wang KY, LaVelle MJ, Gazgalis A, Bender JM, Geller JA, Neuwirth AL, Cooper HJ, Shah RP. Bilateral total knee arthroplasty: current concepts review. JBJS Rev. 2023;11(1):e22.
11. Kumar K, Railton C, Tawfic Q. Tourniquet application during anesthesia: "What we need to know?" J Anaesthesiol Clin Pharmacol. 2016;32(4):424-30.
12. Tai TW, Lin CJ, Jou IM, Chang CW, Lai KA, Yang CY. Tourniquet use in total knee arthroplasty: a meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2011;19:1121-30.
13. Alcelik I, Pollock RD, Sukeik M, Bettany-Saltikov J, Armstrong PM, Fismer P. A comparison of outcomes with and without a tourniquet in total knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials. J Arthroplasty. 2012;27(3):331-40.
14. Deering EM, Hu SY, Abdulkarim A. Does tourniquet use in TKA increase postoperative pain? A systematic review and meta-analysis. Clin Orthop Relat Res. 2019;477(3):547-58.

Outcomes of Vascularized Lymph Node Transfer Treatment in Patients with Lymphedema

Boonyaporn Kotistienkul, M.D., Min Yongsuvimol, M.D., Nattanit Poungjantaradej, M.D., Sitthichoke Taweepraditpol, M.D.*

Division of Plastic Surgery, Department of Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.



*Corresponding author: Sitthichoke Taweepraditpol
E-mail: ntdclub13@gmail.com
Received 3 January 2025 Revised 28 January 2025 Accepted 28 January 2025
ORCID ID: http://orcid.org/0009-0008-1706-8032
https://doi.org/10.33192/smj.v77i6.272983

ABSTRACT

Objective: This study aimed to evaluate the postoperative outcomes of patients with lymphedema treated with vascularized lymph node transfer (VLNT).

Materials and Methods: A retrospective chart review was conducted on 28 patients who underwent VLNT procedures at Siriraj Hospital between 2010 and 2020. Data collected included patient demographics, underlying diseases, previous cancer treatments, duration of lymphedema, etiology of lymphedema, donor and recipient sites, operative time, and limb circumference measurements were taken pre-operatively and at 1, 3, 6, and 12 months postoperatively. Additionally, postoperative complications were documented and analyzed.

Results: The review identified various underlying diseases associated with lymphedema, mostly linked to cancer. Noteworthy cancer treatments included node dissection, radiotherapy, and chemotherapy. The etiology of lymphedema varied, with multiple donor and recipient sites used for VLNT procedures. Postoperative limb circumference measurements showed significant percentage reduction in limb circumference, particularly in patients with upper limb lymphedema ($p<0.05$), while the lower limb showed no statistical significance. Postoperative complications included flap necrosis, flap congestion, flap hematoma, and cellulitis.

Conclusion: Our retrospective analysis underscores the effectiveness of VLNT procedures in managing lymphedema at Siriraj Hospital. Despite the diverse etiologies and prior treatments, VLNT demonstrated favorable outcomes in terms of limb circumference reduction, particularly in upper extremities. Further prospective analytic studies are warranted to validate these findings and optimize treatment protocols.

Keywords: Vascular lymph nodes transfer (VLNT); lymphedema; limb circumference; postoperative reduction; postoperative complication (Siriraj Med J 2025; 77: 427-435)

INTRODUCTION

Lymphedema is a chronic condition characterized by impaired lymphatic drainage, leading to limb swelling and tissue changes such as adipose tissue deposition and skin thickening.[1,2] Lymphedema is classified into two etiological groups: primary and secondary lymphedema. While primary lymphedema is typically caused by congenital abnormalities or developmental defects in the lymphatic system, secondary lymphedema often results from surgical interventions, trauma, or underlying medical conditions that disrupt lymphatic flow, such as cancer.[3-5]

Common symptoms of lymphedema include pain, heaviness, swelling, decreased limb function, decreased quality of life, skin changes and recurrent infections. Diagnosis is often based on limb circumference or volume measurements, with differences of 2 cm or more in limb circumference compared to the contralateral limb, or volume differences of 200 mL or 10% from baseline, considered diagnostic.[6]

Management of lymphedema consists of nonoperative and surgical treatment. The nonoperative treatment started with decongestive therapy (CDT), while surgical treatment is mostly second-line therapy, offered after unsuccessful CDT. The surgical treatment can be classified into debulking procedures; direct excision (Charles or Sistrunk procedure) and liposuction, and physiologic procedures; lymphatic bypass and lymph node transplants.[7] The emerging surgical procedure including lymphaticovenous anastomosis (LVA), vascularized lymph node transfer (VLNT), liposuction and Charles procedure.[8] VLNT involves transferring lymphatic tissue to an area of lymph obstruction to reconstruct the affected part. Lymph nodes for VLNT can be harvested from various donor sites, including the groin, submental region, supraclavicular, area, thoracodorsal region, lateral thoracic region, internal mammary region, deep inferior epigastric, lateral intercostal artery region, gastroepiploic, jejunal mesentery, mesoappendix and ileocecal area.[9-15] The mechanism of VLNT consist of 2 main actions, of which are lymphatic pump, which is an immediate action and lymphangiogenesis which requires time. Therefore, VLNT is indicated for patients whose lymphatic vessels are impaired, higher stage of ISL, or failure of prior LVA.[7]

This study focuses on the surgical outcomes of patients treated with VLNT at Siriraj Hospital between 2010 and 2020. The analysis includes postoperative limb circumferences, complications, and percentage reduction in limb circumference.

MATERIALS AND METHODS

A case series study was conducted with approval from the Institutional Review Board (IRB) of the Faculty of Medicine Siriraj Hospital No. 073/2566, COA No. Si 187/2023. The study focused on patients diagnosed

with lymphedema who underwent VLNT using lymph nodes harvested from the supraclavicular, submental, omentum, or other donor sites between 2010 and 2020. Demographic data, including age, sex, weight, height, and underlying disease(s) were collected. Patients were graded according to ISL staging, primary or secondary lymphedema, and the location of affected limb(s). Operational data included the donor site location and the duration of the operation were collected.

Limb circumferences were measured using a standardized approach with five anatomical reference points. For the upper extremities, measurements were taken at 20 cm above the olecranon (Site 1), 10 cm above the olecranon (Site 2), 10 cm below the olecranon (Site 3), 20 cm below the olecranon (Site 4), and mid palm (Site 5). For the lower extremities, measurements were taken at 20 cm above the patella (Site 1), 10 cm above the patella (Site 2), 10 cm below the tibial tuberosity (Site 3), 10 cm above the medial malleolus (Site 4), and the mid-arch of the foot (Site 5).

The outcomes were evaluated by comparing pre-operative and postoperative limb circumferences at 1, 3, 6, and 12 months. Results were calculated as the percentage of limb circumference reduction. Additional postoperative complications, including flap loss, flap congestion, hematoma, lymphocele, and infection were assessed and compared across donor site areas.

Baseline data were summarized using descriptive statistics, presented as medians with percentile 25 and percentile 75 (Q1, Q3), mean with standard deviations (SD), or frequencies with percentages as appropriate. Due to repeated measures of outcomes over time and missing data, generalized estimating equations (GEE) was employed. The dependent variable was percentage reduction in limb circumference from baseline and independent variable was time as a factor. To assess change over time, only subjects with at least two values of percentage reduction were included in GEE model. The correlation among repeated outcomes was tested using corrected quasi likelihood under the independent model criterion (QICC) and resulted in exchangeable correlation structure. Results from GEE were presented as estimated mean, standard error (SE) and p-value. A p-value of <0.05 was considered statistically significant. All statistical analyses were performed using IBM SPSS 29.

Ethical considerations were upheld throughout the study in accordance with the principles of the Declaration of Helsinki. Patient confidentiality was rigorously maintained by anonymizing patient data during both analysis and reporting.

RESULTS

Demographic Data

A retrospective analysis was conducted on 43 patient charts. Fifteen patients were excluded due to missing data or insufficient data. Thus, the final analysis included 28 patients, consisting of 26 females (92.9%) and 2 males (7.1%). This examination provided valuable insights into the complex management of lymphedema. The mean age of the patients was 61.1 ± 12.9 years the mean BMI was 27.4 ± 5.6 kg/m^2. Gynecological cancer was the most common underlying condition, affecting 13 patients (46.4%), followed by breast cancer, which accounted for 8 cases (28.6%). Additionally, 6 patients (21.4%) were diagnosed with primary lymphedema, and one patient (3.6%) presented with lymphedema caused by other factors, such as trauma (Table 1).

Among patients with cancer-related lymphedema, prior treatments played a significant role in disease progression and management. The analysis revealed that 14 patients had undergone radiotherapy, 12 had received chemotherapy, and seven had undergone node dissection. These findings highlight the prevalence of these treatments and intricate relationship between cancer therapies and the development of secondary lymphedema, emphasizing the importance of comprehensive preoperative assessments and tailored surgical interventions to optimize patient outcomes.

The average duration of lymphedema before diagnosis by a specialized professional was 3.5 years. Concurrently, patients experienced an average of 1 episodes of infection. Among the 28 patients, 11 had undergone LVA prior to VLNT, one had a failed outcome from a prior VLNT procedure, and another had undergone liposuction before VLNT. Patients were also categorized based on their ISL staging. Seven patients (25.0%) were classified as ISL stage 1, 18 patients (64.3%) as ISL stage 2, and three patients (10.7%) as ISL stage 3. Regarding the location of lymphedema, 19 patients were diagnosed with lower extremity lymphedema, of whom 12 (42.9%) had lymphedema in the left leg and seven patients (25.0%) in the right leg. Additionally, nine patients presented with upper extremity lymphedema, with four patients (14.3%) experiencing lymphedema in the left arm and five patients (17.9%) in the right arm.

Surgical Outcomes and Parameters

The mean operative duration for VLNT procedures was 6.8 ± 1.5 hours, highlighting the complexity of microsurgical techniques employed. The average hospital stay was 11.0 days with mean follow-up time of 18.9 months. Among the 28 patients who underwent VLNT,

TABLE 1. Demographic Characteristics of Patients Who Received VLNT.

Demographic Data of Patients Who Received VLNT	
Etiology (%)	
Ob-Gyn Cancer Related	13 (46.4)
HNB Cancer Related	8 (28.6)
Non-Cancer Related	1 (3.6)
Primary	6 (21.4)
Cancer Treatment	
Surgery	19 (67.9)
Node Dissection	7 (25.0)
Chemotherapy	12 (42.9)
Radiotherapy	14 (50.0)
Lymphedema Duration (year): Median [Q1, Q3]	3.5 [1.25, 9.75]
Previous Infection (episodes): Median [Q1, Q3]	1.0 [0.0, 3.0]
Previous Lymphedema Treatment (%)	
Lymphaticovenous anastomosis (LVA)	11 (39.3)
Vascular Lymph Node Transfer (VLNT)	1 (3.6)
Liposuction	1 (3.6)
ISL (%)	
1	7 (25.0)
2	18 (64.3)
3	3 (10.7)
Location (%)	
Left Arm	4 (14.3)
Right Arm	5 (17.9)
Left Leg	12 (42.9)
Right Leg	7 (25.0)

23 (85.2%) were categorized as having successful outcomes, while 4 patients (14.8%) were classified as failed surgeries, with one additional patient lost to follow-up. Postoperative complications were delineated into four categories: flap congestion, flap necrosis, hematoma, and cellulitis, affecting three, two, two and five patients, respectively. Overall, 14 patients (51.9%) experienced postoperative infections, while 13 patients (48.1%) remained infection-free. Additionally, patients were categorized based on donor and recipient sites. Donor sites included the supraclavicular (7 patients, 25%), submental (7 patients, 25%), and omental (14 patients, 50%) area. Recipient sites included the axilla (1 patient, 3.6%), wrist (8 patients, 28.6%), thigh (3 patients, 10.7%), calf (8 patients, 28.6%), ankle (6 patients, 21.4%), and dorsum of the foot (2 patients, 7.1%) (Table 2).

Quantitative measurements, including preoperative and postoperative limb circumference assessments, were essential for evaluating treatment efficacy and tracking disease progression longitudinally. We calculated the percentage reduction in limb circumference by comparing preoperative measurements to postoperative results at 1, 3, 6, and 12 months, respectively. The findings revealed that patients with upper extremity lymphedema patients showed the highest percentage reduction in limb circumference at 12 months postoperatively, particularly at site 3, with a reduction of 9.68%. Conversely, patients with lower extremity lymphedema demonstrated the greatest

TABLE 2. Surgical Outcomes and Parameters of Lymphedema Patients Who Received VLNT.

Surgical Outcomes and Parameters of Lymphedema Patients Who Received VLNT	
Operative Time (hours): Mean ± SD	6.8 ± 1.5
Hospital Stay (days): Median [Q1, Q3]	11.0 [9.5, 21.0]
Mean Follow-up Time (months): Median [Q1, Q3]	18.9 [13.7, 37.6]
Donor Site (%)	
Supraclavicular	7 (25.0)
Submental	7 (25.0)
Omentum	14 (50.0)
Recipient Sites (%)	
Axilla	1 (3.6)
Wrist	8 (28.6)
Thigh	3 (10.7)
Calf	8 (28.6)
Ankle	6 (21.4)
Dorsum of foot	2 (7.1)
Operation Results (%)	
Success	23 (85.2)
Failed	4 (14.8)
Complications (%)	
Flap Necrosis	3 (11.1)
Flap Congestion	2 (7.4)
Hematoma	2 (7.4)
Postoperative Infection (%)	
No 13 (48.1)	
Yes	14 (51.9)

percentage reduction in limb circumference at site 1, 6 months postoperatively, with a reduction of 3.56%. For upper extremity lymphedema patients, the percentage reduction in limb circumference progressed from most reduction to least at 12, 1, 6, and 3 months postoperatively, respectively. For lower extremity lymphedema patients, the percentage reduction in limb circumference, the order was 6, 3, 1, and 12 months, respectively, from most to least reduction. Fig 1 and 2 illustrate the postoperative percentage reduction in limb circumference relative to preoperative measurements, where a negative value indicates a decrease in limb circumference, while a positive value indicates an increase in limb circumference compared to the baseline.

The table below showed the mean percentage limb reduction with standard error (SE) in relation to the follow-up time at 1, 3, 6, and 12 months post-operatively (Table 3). The p-value showed significantly reduction in the upper extremities especially in 12 months post-operative (Table 3a), while the lower extremities showed most reduction at 6 months post-operative (Table 3b). The table illustrated that the upper extremities benefit from the VLNT treatment the most, with the significant reduction shown in most of the site and follow-up month, while the lower extremities showed no statistical significance in the percentage reduction. However, the dynamic and trend of the outcome can still be seen from the outcomes.

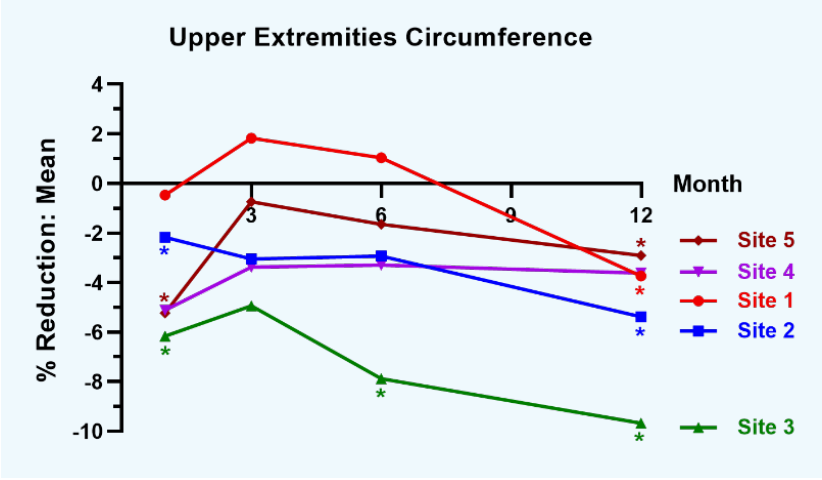


Fig 1. Postoperative Percent Reduction in Limb Circumference Among Upper Extremity Lymphedema Patients Compared to Preoperative Measurements

Upper extremities landmarks starting at 20 cm above olecranon (Site 1), 10 cm above olecranon (Site 2), 10 cm below olecranon (Site 3), 20 cm below olecranon (Site 4), and mid palm (Site 5). The (*) in the graph indicated statistical significance at the point of time and site.

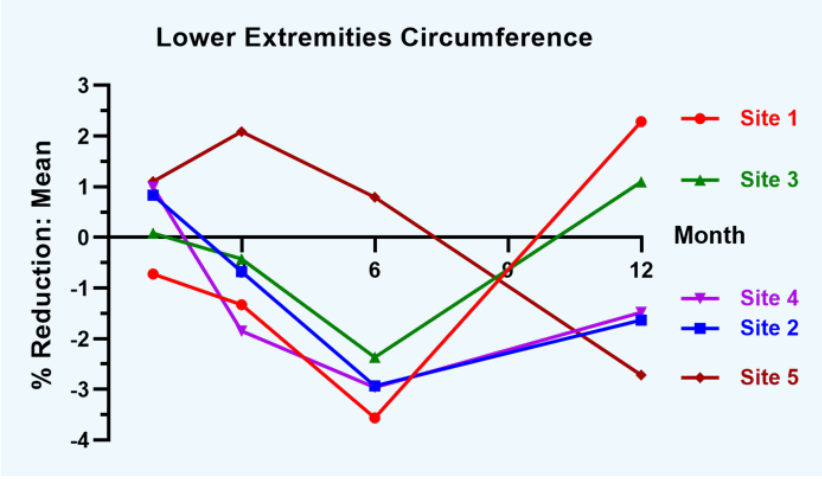


Fig 2. Postoperative Percent Reduction in Limb Circumference Among Lower Extremity Lymphedema Patients Compared to Preoperative Measurements

Lower extremities landmarks starting at 20 cm above patella (Site 1), 10 cm above patella (Site 2), 10 cm below tibial tuberosity (Site 3), 10cm above medial malleolus (Site 4), and mid-arch of the foot (Site5)

DISCUSSION

The comprehensive retrospective analysis of 28 patient charts demonstrated the complexities of lymphedema management. The predominance of female patients in our study (92.9%) aligns with the higher prevalence of lymphedema among women, emphasizing the need for gender-specific considerations in lymphedema management. The mean age of our patient cohort (61.07 years) underscores the significance of lymphedema as a condition commonly affecting older individuals, necessitating age-appropriate strategies in treatment planning and care. Cancer also was a major contributor to lymphedema, with up to 75.0% of patients having cancer including gynecological cancers, particularly breast cancer.

The comparison of postoperative and preoperative limb circumference measurements provides valuable insights into the effectiveness of surgical interventions in reducing limb volume and managing lymphedema. Our findings highlight the dynamic nature of lymphedema management, with significant differences observed across various measurement sites and time points. Notably, the findings revealed significant reduction in upper limb circumference with the highest percentage at 12 months postoperatively, with a reduction of 11.063%. Conversely, the greatest percentage reduction in lower limb circumference at 6 months postoperatively, with a reduction of 7.029%. These findings underscore the efficacy of surgical interventions, such as vascularized lymph node transfer (VLNT), in restoring lymphatic function especially in the upper extremities.

The variation in response to surgical interventions between upper and lower extremity lymphedema patients underscores the importance of tailoring treatment strategies to individual patient characteristics and disease severity. Furthermore, the calculated percentage reduction in limb circumference provides quantitative evidence of treatment efficacy, with upper extremity lymphedema patients demonstrating the highest percentage reduction at 12 months postoperatively and lower extremity lymphedema patients exhibiting the greatest reduction at 6 months postoperatively.

Compared to prior research, *Brown et al.* (2023) conducted an extensive review of studies evaluating

TABLE 3. Estimated mean of percent reduction at each month and site by Generalized Estimating Equations (GEE).

(a) Upper Extremities Circumference

Site		% Reduction from baseline Month 1	Month 3	Month 6	Month 12
1	Mean (SE)	-0.47 (1.29)	1.82 (1.54)	1.03 (1.86)	-3.74 (1.89)
	p-value	0.717	0.238	0.580	**0.048**
2	Mean (SE)	-2.18 (1.09)	-3.06 (1.93)	-2.94 (1.77)	-5.39 (2.19)
	p-value	**0.046**	0.112	0.096	**0.014**
3	Mean (SE)	-6.17 (1.61)	-4.94 (3.21)	-7.89 (3.28)	-9.68 (3.09)
	p-value	**<0.001**	0.124	**0.016**	**0.002**
4	Mean (SE)	-5.12 (3.47)	-3.37 (3.22)	-3.30 (3.72)	-3.62 (2.91)
	p-value	0.141	0.295	0.375	0.213
5	Mean (SE)	-5.23 (1.89)	-0.74 (2.50)	-1.65 (1.34)	-2.91 (1.39)
	p-value	**0.006**	0.767	0.220	**0.035**

(b) Lower Extremities Circumference

Site		% Reduction from baseline Month 1	Month 3	Month 6	Month 12
1	Mean (SE)	-0.73 (1.84)	-1.33 (2.99)	-3.56 (2.16)	2.29 (3.15)
	p-value	0.694	0.656	0.100	0.468
2	Mean (SE)	0.83 (2.40)	-0.68 (3.18)	-2.93 (2.88)	-1.64 (3.19)
	p-value	0.728	0.831	0.308	0.608
3	Mean (SE)	0.08 (2.46)	-0.43 (2.72)	-2.37 (2.23)	1.10 (2.81)
	p-value	0.975	0.874	0.288	0.697
4	Mean (SE)	0.99 (2.75)	-1.85 (2.22)	-2.97 (1.63)	-1.49 (3.09)
	p-value	0.718	0.403	0.069	0.631
5	Mean (SE)	1.10 (1.16)	2.09 (2.10)	0.79 (1.61)	-2.72 (1.79)
	p-value	0.342	0.319	0.623	0.128

Lower extremities landmarks starting at 20 cm above patella (Site 1), 10 cm above patella (Site 2), 10 cm below tibial tuberosity (Site 3), 10 cm above medial malleolus (Site 4), and mid-arch of the foot (Site 5)

outcomes following VLNT, addressing factors such as limb measurements, bio-impedance, Patient-Reported Outcome Measures (PROMs), cellulitis, and complications.[22] While our study primarily focuses on limb circumference measurements and percentage reduction, our findings aligned with the broader consensus that VLNT offered significant advantages in managing lymphedema. The observed improvements in postoperative complications further validate the effectiveness of VLNT as a therapeutic approach for managing lymphedema. Similarly, *Ciudad et al.* (2019) performed a comparative examination of clinical outcomes in upper and lower extremity lymphedema, suggesting potential benefits of VLNT, particularly in upper extremity cases.[24] Our findings supported these findings, demonstrating favorable outcomes in upper extremity lymphedema, including significant reductions in limb volume over the follow-up period. However, our research not only showed the similar outcome, but also showed the dynamic nature of the limb reduction, where the circumferences can vary with time. This highlights

the potential advantages of VLNT in addressing upper extremity lymphedema and emphasizes the importance of tailoring treatment strategies to specific anatomical considerations.

Numerous studies have investigated lymphedema treatment, including comprehensive reviews of VLNT outcomes,[16,17] complications,[18-20] and meta-analysis of VLNT efficacy in lymphedema treatment.[21-23] *Meuli et al.* (2023) conducted a meta-analysis of microsurgical treatments for lymphedema, concluding that both LVA and VLNT are effective in reducing the severity of secondary lymphedema.[21] *Brown et al.* (2023) reviewed studies that evaluated outcomes such as limb-measurement, bio-impedance, Patient-Reported-Outcome-Measures (PROMs), cellulitis and complications at 1 and 2 years post-VLNT.[22] Similarly, *Ciudad et al.*[24] compared clinical outcomes between upper and lower extremity lymphedema, finding that VLNT may provide greater benefits for upper extremities, a result consistent with *Ward et al.'s* meta-analysis.[23]

A limitation of this study is the relatively small number of VLNT cases at Siriraj Hospital. Lymphedema is not the most common cause of limb edema and is often misdiagnosed,[25] resulting in a limited number of lymphedema cases, and an even smaller cohort receiving VLNT treatment. Despite this limitation, our research focused specifically on patients with VLNT at Siriraj Hospital and included sequential follow-up evaluations. This approach provided more detailed insights into the progression of postoperative outcomes compared to methods used in previous studies.

These findings highlight the importance of longitudinal assessment and monitoring in evaluating treatment outcomes and guiding therapeutic decision-making in lymphedema management. By employing objective metrics such as limb circumference measurements and percentage reduction, clinicians can track disease progression, assess treatment response, and optimize patient care strategies. Moving forward, further research should explore the long-term efficacy and durability of surgical interventions, as well as identify predictive factors associated with treatment success across different patient subgroups. Overall, our study underscored the dynamic nature of lymphedema management and emphasized the importance of individualized, multidisciplinary approaches to optimize patient outcomes and enhance quality of life.

CONCLUSION

Our study underscores the importance of a multidisciplinary approach to lymphedema care, integrating surgical expertise with comprehensive assessment and rehabilitation. Tailored interventions, such as VLNT, demonstrated significant potential in reducing limb volume and managing complications. The VLNT showed better result in reducing upper extremities lymphedema than in lower extremities lymphedema. The study also showed the dynamic result compared to time of follow-up. Therefore, the study suggests VLNT as a surgical option for upper extremities lymphedema patients. However, further analytic research is suggested to refine treatment strategies, identify predictive factors, and enhance patient care. By advancing our understanding and refining approaches, we can improve outcomes and enhance the quality of life for individuals living with lymphedema.

Data Availability Statement

The authors confirm that the data supporting the finding of this study are available within the article and its supplementary materials.

ACKNOWLEDGEMENTS

We are thankful for Chulaluk Komoltri, DrPH for assisting with the revision of the statistical analysis.

DECLARATIONS

Grants and Funding Information

None.

Conflict of Interest

The authors declare no conflict of interest.

Registration Number of Clinical Trial

Not applicable.

Author Contributions

Conceptualization and methodology, N.P, and S.T. ; Investigation, N.T., and S.T. ; Formal analysis, B.K., and M.Y. ; Visualization and writing – original draft, B.K., M.Y., and S.T. ; Writing – review and editing, B.K., and S.T. ; Supervision, S.T. All authors have read and agreed to the final version of the manuscript.

Use of Artificial Intelligence

The study does not use artificial intelligence for the manuscript.

Human Ethics Approval Declaration

The study was conducted with approval from the Institutional Review Board (IRB) of the Faculty of Medicine Siriraj Hospital No. 073/2566, COA No. Si 187/2023.

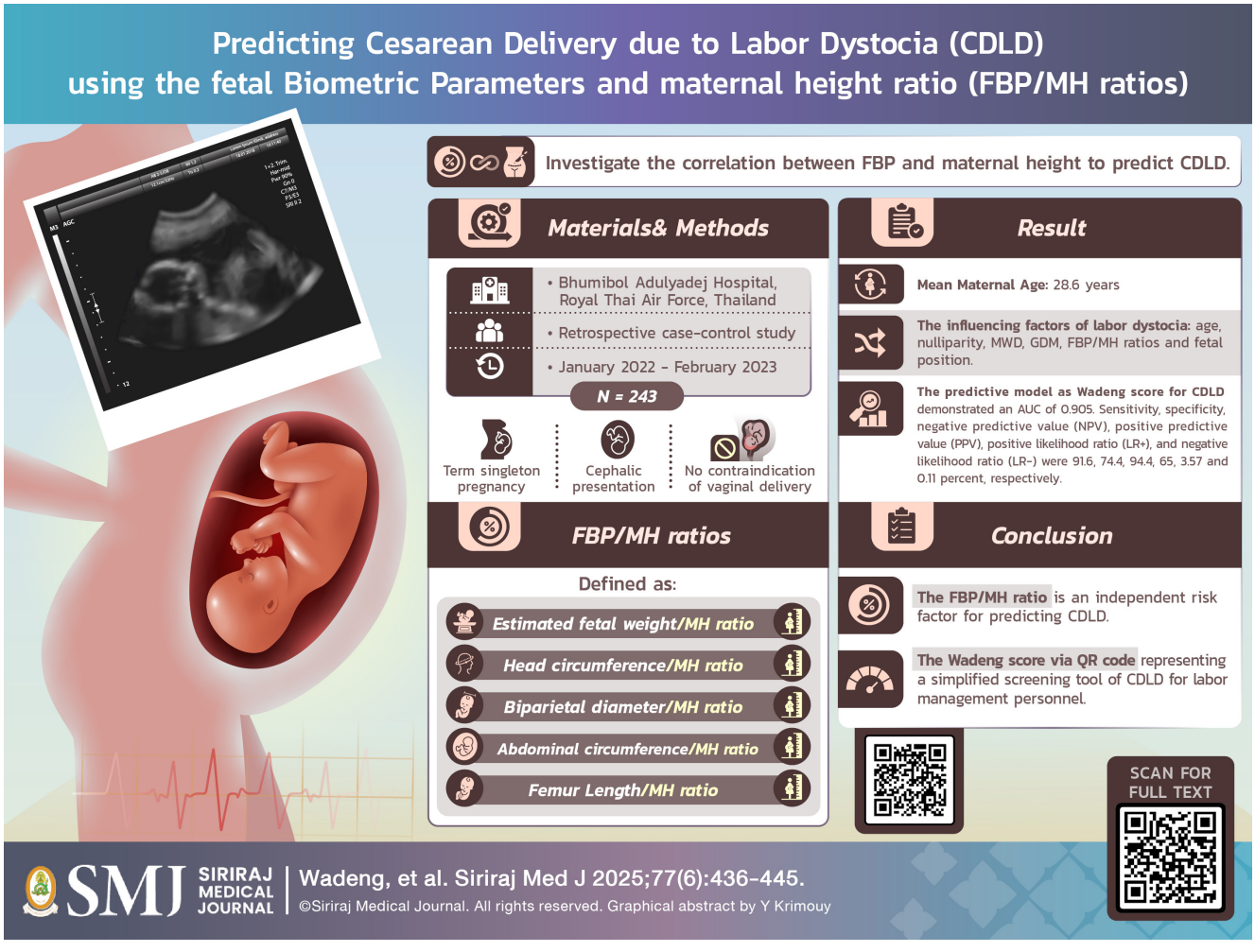
REFERENCES

1. Mehrara BJ, Coriddi M, Dayan J, Kataru R. Lymphedema. In: Elsevier eBooks [Internet]. 2021. p. 666–83. Available from: https://doi.org/10.1016/b978-0-323-65381-7.00044-7
2. Damstra RJ, Hendrickx AA, Van Duinen K, Klinkert P, Dickinson-Blok JL. Diagnostiek en behandeling van primair en secundair lymfoedeem [Internet]. NTVG. 2022. Available from: https://www.ntvg.nl/artikelen/diagnostiek-en-behandeling-van-primair-en-secundair-lymfoedeem
3. Sleigh BC, Manna B. Lymphedema [Internet]. StatPearls - NCBI Bookshelf. 2023. Available from: https://www.ncbi.nlm.nih.gov/books/NBK537239/
4. Greene AK, Borud L, Slavin SA. Blood pressure monitoring and venipuncture in the lymphedematous extremity. Plastic & Reconstructive Surgery [Internet]. 2005 Dec 1;116(7):2058–9. Available from: https://doi.org/10.1097/01.prs.0000192621.97804.d4
5. Mongkronwong A, Nilkarn C, Akaranuchat N. What do we know about lymphedema? review article. Siriraj Medical Journal [Internet]. 2021 Apr 19;73(5). Available from: https://doi.org/10.33192/smj.2021.39
6. Dayan JH, Ly CL, Kataru RP, Mehrara BJ. Lymphedema: pathogenesis and novel therapies. Annual Review of Medicine [Internet]. 2017 Sep 6;69(1):263–76. Available from: https://doi.org/10.1146/annurev-med-060116-022900
7. Neligan P C., Song D H., Hong J Pio, Liu D Z., editors. Lower Extremity Surgery. In: Plastic Surgery Lower Extremity, Trunk and Burns. 5th edition. Elsevier Inc.; 2024. p. 76–110.
8. Treating Lymphedema [Internet]. John Hopkins Medicine. 2022. Available from: https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/treating-lymphedema
9. Becker C, Assouad J, Riquet M, Hidden G. Postmastectomy lymphedema. Annals of Surgery [Internet]. 2006 Feb 17;243(3):313–5. Available from: https://doi.org/10.1097/01.sla.0000201258.10304.16
10. Cheng MH, Huang JJ, Nguyen DH, Saint-Cyr M, Zenn MR, Tan BK, et al. A novel approach to the treatment of lower extremity lymphedema by transferring a vascularized submental lymph node flap to the ankle. Gynecologic Oncology [Internet]. 2012 Apr 17;126(1):93–8. Available from: https://doi.org/10.1016/j.ygyno.2012.04.017
11. Akita S, Mitsukawa N, Kuriyama M, Kubota Y, Hasegawa M, Tokumoto H, et al. Comparison of vascularized supraclavicular lymph node transfer and lymphaticovenular anastomosis for advanced stage lower extremity lymphedema. Annals of Plastic Surgery [Internet]. 2015 Apr 15;74(5):573–9. Available from: https://doi.org/10.1097/sap.0000000000000513
12. Attash SM, Al-Sheikh MY. Omental flap for treatment of long standing lymphoedema of the lower limb: can it end the suffering? Report of four cases with review of literatures. BMJ Case Reports [Internet]. 2013 Feb 8;bcr2012008463. Available from: https://doi.org/10.1136/bcr-2012-008463
13. Ciudad P, Kiranantawat K, Sapountzis S, Yeo MS, Nicoli F, Maruccia M, et al. Right gastroepiploic lymph node flap. Microsurgery [Internet]. 2014 Oct 30;35(6):496–7. Available from: https://doi.org/10.1002/micr.22344
14. Lin CH, Ali R, Chen SC, Wallace C, Chang YC, Chen HC, et al. Vascularized groin lymph node transfer using the wrist as a recipient site for management of postmastectomy upper extremity lymphedema. Plastic & Reconstructive Surgery [Internet]. 2009 Apr 1;123(4):1265–75. Available from: https://doi.org/10.1097/prs.0b013e31819e6529
15. Sapountzis S, Singhal D, Ciudad P, Meo D, Chen HC. Lymph node flap based on the right transverse cervical artery as a donor site for lymph node transfer. Annals of Plastic Surgery [Internet]. 2015 Mar 18;74(6):744–5. Available from: https://doi.org/10.1097/sap.0000000000000422
16. Yodrabum N, Patchanee K, Oonjitti T, Piyaman P. Technical Challenges in "Micro" Lymph Node Identification during Vascularized Submental Lymph Node Flap Harvesting. Plastic & Reconstructive Surgery Global Open [Internet]. 2020 Dec 1;8(12):e3330. Available from: https://doi.org/10.1097/gox.0000000000003330
17. Pons G, Masia J, Loschi P, Nardulli ML, Duch J. A case of donor-site lymphoedema after lymph node–superficial circumflex iliac artery perforator flap transfer. Journal of Plastic Reconstructive & Aesthetic Surgery [Internet]. 2013 Jul 1;67(1):119–23. Available from: https://doi.org/10.1016/j.bjps.2013.06.005
18. Scaglioni MF, Arvanitakis M, Chen Y, Giovanoli P, Yang JC, Chang EI. Comprehensive review of vascularized lymph node transfers for lymphedema: Outcomes and complications. Microsurgery [Internet]. 2016 Jun 7;38(2):222–9. Available from: https://doi.org/10.1002/micr.30079
19. Ozturk CN, Ozturk C, Glasgow M, Platek M, Ashary Z, Kuhn J, et al. Free vascularized lymph node transfer for treatment of lymphedema: A systematic evidence based review. Journal of Plastic Reconstructive & Aesthetic Surgery [Internet]. 2016 Jul 3;69(9):1234–47. Available from: https://doi.org/10.1016/j.bjps.2016.06.022
20. Pappalardo M, Patel K, Cheng M. Vascularized lymph node transfer for treatment of extremity lymphedema: An overview of current controversies regarding donor sites, recipient sites and outcomes. Journal of Surgical Oncology [Internet]. 2018 Mar 24;117(7):1420–31. Available from: https://doi.org/10.1002/jso.25034
21. Meuli JN, Guiotto M, Elmers J, Mazzolai L, Di Summa PG. Outcomes after microsurgical treatment of lymphedema: a systematic review and meta-analysis. International Journal of Surgery [Internet]. 2023 Apr 14;109(5):1360–72. Available from: https://doi.org/10.1097/js9.0000000000000210
22. Brown T, Brown S, Coriddi M, Mehrara BJ, Dayan JH. 43. A Decade of Vascularized Lymph Node Transplant (VLNT) for the Treatment of Lymphedema: A Meta-analysis of Prospective Clinical Trials. Plastic & Reconstructive Surgery Global Open [Internet]. 2023 Apr 1;11(4S):21. Available from: https://doi.org/10.1097/01.gox.0000934292.51809.d7
23. Ward J, King I, Monroy-Iglesias M, Russell B, Van Hemelrijck M, Ramsey K, et al. A meta-analysis of the efficacy of vascularised lymph node transfer in reducing limb volume and cellulitis episodes in patients with cancer treatment-related lymphoedema. European Journal of Cancer [Internet]. 2021 May 20;151:233–44. Available from: https://doi.org/10.1016/j.ejca.2021.02.043
24. Ciudad P, Manrique OJ, Bustos SS, Coca JJP, Chang C, Shih P, et al. Comparisons in long-term clinical outcomes among patients with upper or lower extremity lymphedema treated with diverse vascularized lymph node transfer. Microsurgery [Internet]. 2019 Sep 6;40(2):130–6. Available from: https://doi.org/10.1002/micr.30508
25. Gasparis AP, Kim PS, Dean SM, Khilnani NM, Labropoulos N. Diagnostic approach to lower limb edema. Phlebology the Journal of Venous Disease [Internet]. 2020 Jul 6;35(9):650–5. Available from: https://doi.org/10.1177/0268355520938283

Sonographic Assessment of Fetal Biometric Parameters and Maternal Height Ratio for Prediction of Cesarean Delivery due to Labor Dystocia

Wiarm Wadeng, M.D.[1], Wanlaya Onwatanasrikul, M.D.[1,*], Nop Khongthon, M.D.[2], Monyada Pleankong, M.D.[1], Sinart Prommas, M.D., Ph.D.[1], Kornkarn Bhamarapravatana, Ph.D.[3], Komsun Suwannaruk, M.D.[4]

[1]Department of Obstetrics and Gynecology, Bhumibol Adulyadej Hospital, Royal Thai Air Force, Thailand, [2]Department of Clinical Epidemiology, Faculty of Medicine, Thammasat University, Thailand, [3]Department of Preclinical Science, Faculty of Medicine, Thammasat University, Pathumthani, Thailand, [4]Department of Obstetrics and Gynecology, Faculty of Medicine, Thammasat University, Pathumthani, Thailand.



**Corresponding Author: Wanlaya Onwatanasrikul*
E-mail: wanlaya.onw@gmail.com
Received 12 January 2025 Revised 31 January 2025 Accepted 31 January 2025
ORCID ID: http://orcid.org/0009-0007-1292-5632
https://doi.org/10.33192/smj.v77i6.273115

ABSTRACT

Objective: To investigate the correlation of fetal biometric parameters (FBP; estimated fetal weight (EFW), head circumference (HC), biparietal diameter (BPD), abdominal circumference (AC) and femur length (FL) and maternal height (MH) ratio to predict cesarean delivery (CD) due to labor dystocia (LD).

Materials and Methods: This retrospective case-control study was conducted at the Department of Obstetrics and Gynecology, Bhumibol Adulyadej Hospital, Bangkok, Thailand, between January 2022 and December 2023. Inclusion criteria were pregnant women with singleton, cephalic presentation, termed and without contraindication of vaginal delivery.

Results: A total of 243 parturients were included in the study, with a mean age of 28.6 years. The cesarean delivery rate was 34.1% (83/243). The predictive model was developed incorporating variables including parity, maternal age, gestational diabetes mellitus (GDM), weight, and the FBP/MH ratio. The predictive model for CD due to LD demonstrated an AUC of 0.905, indicating excellent performance. Sensitivity, specificity, negative predictive value (NPV), positive predictive value (PPV), positive likelihood ratio (LR+), and negative likelihood ratio (LR-) were 91.6, 74.4, 94.4, 65, 3.57 and 0.11 percent, respectively.

Conclusion: The FBP/MH ratio is an independent risk factor for predicting CD due to LD. The predictive model of CD due to LD gave sensitivity, specificity, NPV and PPV at percentages of 91.6, 74.4, 65 and 94.4 respectively. This model might be a simple screening tool for labor attending personnel.

Keywords: Labor dystocia; fetal biometric parameters; maternal height; cesarean delivery (Siriraj Med J 2025; 77: 436-445)

INTRODUCTION

Labor dystocia (LD), or difficult labor, is defined as abnormally slow progression or arrest of labor; it is the most common indication for primary cesarean delivery (CD) in nulliparous women when diagnosed during the birthing process. Approximately one-third of the primary cesarean indications are LD.[1-3] Adverse outcomes of cesarean delivery include hemorrhage, infection and neonatal compromise.[4]

The current evaluation of pelvimetry typically relies only on digital interrogation of the bony pelvis to measure cervical dilation as well as fetal and head positions during parturition. However, digital examination is a subjective method that allows for interpersonal variation among practitioners.[1]

Estimated fetal weight (EFW) and fetal head circumference (FHC) have been reported to affect the odds of successful vaginal delivery. In fact, the compatibility between FHC and maternal pelvis is a key factor for successful vaginal delivery.[5-7] A previous study proposed the use of FHC to maternal height (MH) ratio for the prediction of labor dystocia risk.[8] Molaei (2022) reported that EFW and FHC ultrasound measurements can be used to predict the need for cesarean section and abnormal dilatation progression.[5] However, studies regarding the Fetal Biometric Parameter (FBP) to MH ratio in predicting labor dystocia are lacking.

This study investigated the correlation and predictive tool between fetal biometric parameters and MH ratio in labor dystocia prediction. The convenience predictive model via smart phone might be generated for real world using.

MATERIALS AND METHODS

Study design

This retrospective case-control study was conducted at the Department of Obstetrics and Gynecology, Bhumibol Adulyadej Hospital (BAH), Thailand, between January 2022 and December 2023. In 2024, this study was approved by the ethics committee of Bhumibol Adulyadej Hospital (BAH) (IRB 69/67).

Data source and study population

This study was conducted on pregnant women who gave birth at BAH between January 2022 and December 2023. The inclusion criteria were women with singleton fetuses that had reached full term (gestational age after 37 weeks) in cephalic presentation with no contraindication to vaginal delivery. Women who underwent cesarean section for any indication other than labor dystocia, namely fetal non-reassuring, fetal distress, or elective cesarean section were excluded. Women diagnosed with labor dystocia based on the American College of Obstetricians and Gynecologists (ACOG)/ Society for

Maternal-Fetal Medicine (SMFM) recommendations for the safe prevention of primary cesarean section were included when the criteria for arrest of dilatation or arrest of labor in the second stage were fulfilled.[9]

Active labor was characterized by fully effaced and at least 6 cm of cervical dilatation, with three contractions per 10 minutes as recorded by tocography. A protracted active phase occurred when, despite 6 cm dilation and ruptured membranes, labor did not progress after 4 hours of adequate uterine activity or 6 hours of oxytocin administration with inadequate contraction and no further dilation. Arrest of labor in the second stage was diagnosed if the active phase lasted two hours in multiparous women or three hours in nulliparous women without fetal head descent.[10]

To enhance the model's effectiveness, missing ultrasound records of FBP, namely estimated fetal weight (EFW), fetal head circumference (FHC), fetal biparietal diameter (FBPD), fetal abdominal circumference (FAC), and fetal femur length (FFL) within the week prior to the delivery, and unqualified diagnosis of LD were excluded before analysis.

Sample size

The sample size was calculated based on the comparison between two different proportions, using the statistical software package STATA (version 18) (StataCorp, College Station, TX, USA). The data were divided into two groups: patients who had cesarean deliveries due to labor dystocia (cases) and those who had vaginal deliveries (controls) in a 1:2 ratio. The proportion of women who underwent cesarean section due to labor dystocia (CDLD) was 0.73. The proportion of women who had vaginal delivery (VD) was 0.53. Using a continuity correction, the sample size was calculated to be 76 for cases and 152 for controls. After accounting for a 10% dropout rate, the adjusted total sample size required was 250 patients, including 84 for cases and 166 for controls to achieve 80% statistical power with a two-sided alpha error of 0.05.

Aim

The primary aim of this study was to investigate the relationship between FBP/MH ratio and CDLD. The secondary aim was to develop and validate a multiparameter risk-based system. Additionally, the study assessed the receiver operating characteristic (ROC) curve to identify cut-off points that correlate with CDLD. Accuracy, sensitivity, specificity, negative predictive value (NPV), positive predictive value (PPV), positive likelihood ratio (LR+), and negative likelihood ratio (LR-) were investigated.

Conventional statistical analysis

Statistical analysis was conducted using the STATA for MacBook, version18. Chi-square test or Fisher's exact test was used to compare the rates of various risk factors between the CDLD and VD groups. Multivariable analysis (logistic regression) was used to explore the potential predictors of CDLD, with a p-value threshold < 0.05. Logistic coefficients were transformed into risk-based systems. Internal validation was performed by bootstrapping procedure.

RESULTS

In the study period, there were 250 cases of termed pregnant women. After exclusions, 243 subjects were recruited in the study as shown in Fig 1. The success rate of vaginal delivery was 65.9% (160/243). Subjects were divided into VD and CDLD groups. The mean age of

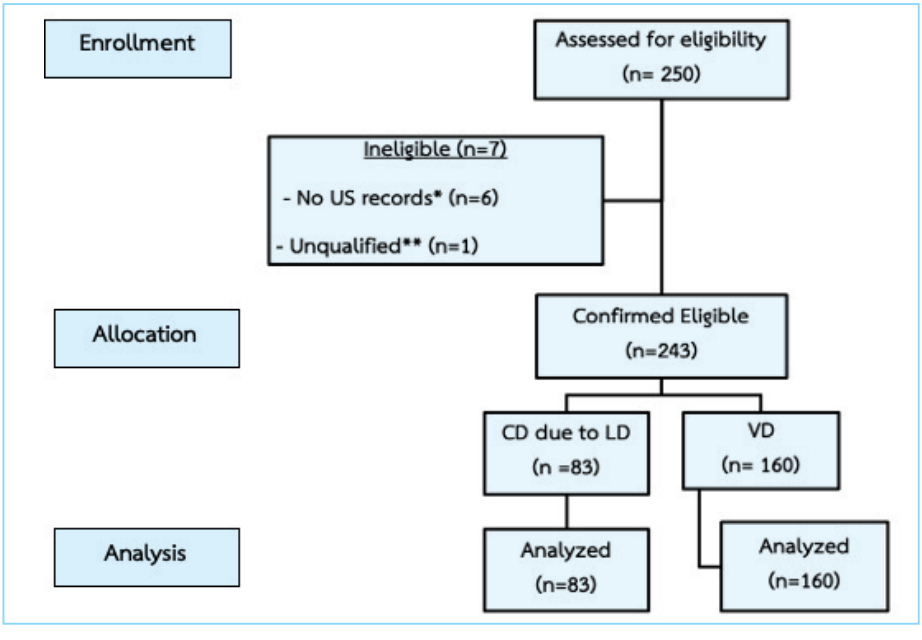


Fig 1. Participant flow diagram.
*No ultrasound records within the week prior to delivery, **Unqualified diagnosis of labor dystocia.
Abbreviations: CD: cesarean delivery, LD: labor dystocia, VD: Vaginal delivery

the parturient and gestational age were 28.6 years and 38.8 weeks, respectively, with no statistically significant differences between groups. Both groups had similar maternal height (MH), total weight gain, and positive gestational diabetes mellitus (GDM) rates. However, the CDLD group had statistically significantly higher pre-pregnancy weight (PPW: 63.5 vs. 58.3 kg), maternal weight at delivery (MWD: 76.3 vs. 70.9 kg), body mass index at delivery (BMI: 30.5 vs 28.3 kg/m^2), and nulliparity (68.7% vs. 41.9%) compared to the VD group.

FBP/MH ratios, including EFW/MH, FHC/MH, FBPD/MH, FAC/MH, and FFL/MH ratios, were significantly higher in the CDLD group compared to the VD group, as shown in Table 1. Additionally, the occiput-posterior position was more frequently found in the CDLD group than in VD group (36.1% vs. 5.6%, p-value < 0.001).

TABLE 1. Baseline characteristics of women included in study and comparison between those who had vaginal delivery (n=160) and those who had caesarean delivery due to labor dystocia (n=83).

	Total*	VD*	CD*	*p*-value
Age (years)	28.6 ± 5.7	28.4 ± 5.9	28.9 ± 5.4	0.569
Nulliparity**	124 (51.0)	67 (41.9)	57 (68.7)	<0.001
GAB (weeks)	38.8 ± 1.2	38.7 ± 1.1	38.9 ± 1.3	0.218
MH (cm)	158.1 ± 6.7	158.2 ± 6.7	157.95 ± 6.8	0.764
PPW (kg)	60.1 ± 14.1	58.3 ± 13.1	63.5 ± 15.1	0.005
MWD (kg)	72.8 ± 14.8	70.9 ± 14.2	76.3 ± 15.2	0.007
TWG (kg)	12.7 ± 7.6	12.7 ± 8.3	12.7 ± 6.0	0.958
BMI at LR (kg/m^2)	29.1 ± 5.6	28.3 ± 5.5	30.5 ± 5.4	0.004
Positive GDM**	39 (16.1)	23 (14.4)	16 (19.3)	0.536
OP position**	39 (16.0)	9 (5.6)	30 (36.1)	<0.001
Male newborn**	127 (52.3)	81 (50.6)	46 (55.4)	0.478
Birth weight (kg)	3.2 ± 0.4	3.1 ± 0.4	3.4 ± 0.4	<0.001
EFW (kg)	3.1 ± 0.4	3.0 ± 0.3	3.4 ± 0.4	<0.001
FBPD (mm)	91.6 ± 3.9	91.1 ± 4.0	92.6 ± 3.4	0.004
FHC (mm)	326.0 ± 12.1	323.4 ± 11.8	330.9 ± 11.0	<0.001
FAC (mm)	328.5 ± 32.9	323.8 ± 28.6	337.6 ± 38.4	0.002
FFL (mm)	69.9 ± 3.4	69.4 ± 3.2	70.8 ± 3.7	0.003
EFW/MH ratio	19.6 ± 2.5	18.7 ± 2.1	21.3 ± 2.4	<0.001
FHC/MH ratio	2.1 ± 0.2	2.1 ± 0.1	2.1 ± 0.1	<0.001
FBPD/MH ratio	0.6 ± 0.0	0.6 ± 0.0	0.6 ± 0.0	0.013
FAC/MH ratio	2.1 ± 0.2	2.1 ± 0.2	2.1 ± 0.3	0.003
FFL/MH ratio	0.4 ± 0.0	0.4 ± 0.0	0.5 ± 0.0	0.008

*mean ± standard deviation (SD), ** n (%)

Abbreviations: MH : maternal height, BMI : body mass index, GDM : gestational diabetes mellitus, GAB: gestational age at birth, EFW : estimated fetal weight, FBPD : fetal biparietal diameter, FHC : fetal head circumference, FAC : fetal abdominal circumference, FFL : fetal femur length, VD : vaginal delivery, CD : cesarean delivery due to labor dystocia, PPW : pre-pregnancy weight, MWD : maternal weight at delivery, TWG : total weight gain, GDM : gestational diabetes screening, OP : occipito posterior position of fetus

Model development

After multivariable logistic analysis, the influencing factors of labor dystocia, specifically: age, nulliparity, MWD, GDM, EFW/MH ratio, FBPD/MH ratio, FHC/MH ratio, FAC/MH ratio, FFL/MH ratio and fetal position were analyzed to construct the predictive model. The receiver operating characteristic (ROC) curve was generated as shown in Fig 2. Area under the curve (AUC) and p-value were 0.9047. The appropriate cut-off point of the model was 0.23 which provided sensitivity, specificity, LR+, LR-, PPV, and NPV at 91.6, 74.4, 3.57, 0.11, 65, and 94.4 percent, respectively.

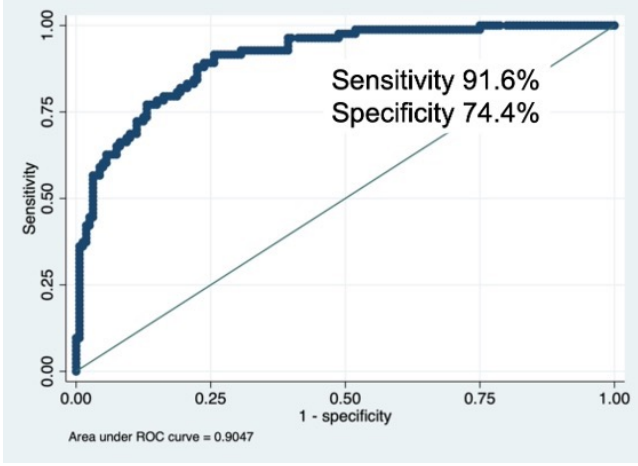


Fig 2. Receiver operating curve (ROC) of Wadeng Score to predict cesarean delivery due to labor dystocia

Abbreviations: PPV: positive predictive value, NPV: negative predictive value, LR+: positive likelihood ratio, and LR-: negative likelihood ratio

Accuracy of predictive model

This model incorporated 10 factors, including age, parity, MWD, FPM/MH ratio (EFW/MH, FHC/MH, FBPD/MH, FAC/MH, FFL/MH ratio), GDM, and fetal position. The probability of the predictive model could be estimated using a combination of 10 factors as illustrated in Table 2. Internal validation was run by the Bootstrap

TABLE 2. Predictors of cesarean delivery due to labor dystocia in Term pregnancy.

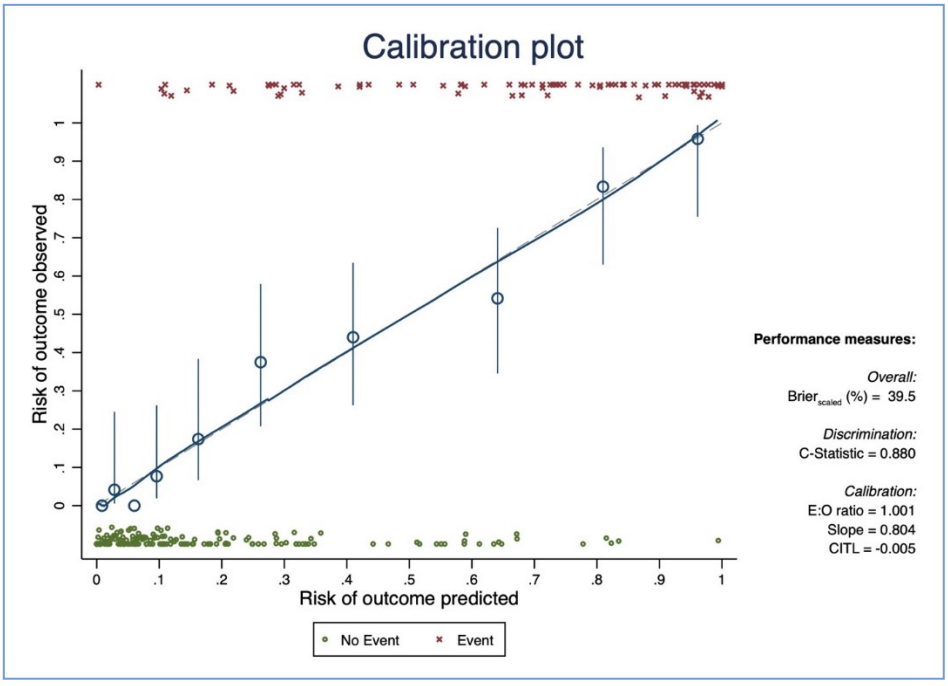
Predictors	coefficient *β*	OR	95% CI	*p*-value
Age	0.0760766	1.08	1.00-1.16	0.035
Parity				
Nulli	1.996217	3.04	1.74-5.33	<0.001
Multi	Ref			
MWD	0.0021692	1.02	1.01-1.04	0.009
Ratio				
EFW/MH	0.8940321	1.69	1.45-1.97	<0.001
FBPD/MH	-2.309326	1.59	1.22-2.07	0.001
FHC/MH	0.3593595	2.95	1.23-7.05	0.015
FAC/MH	-0.2086456	1.36	1.13-1.64	0.001
FFL/MH	-1.265261	1.69	1.45-1.97	<0.001
GDM				
Yes	-0.4003198	1.50	0.72-3.13	0.275
No screening	0.7847241	1.18	0.64-2.18	0.598
No	Ref			
Position				
OP	2.42365	9.50	4.23-21.30	<0.001
OA	Ref			

Formula of model : $\exp^z/(1+\exp^z)$, where Z = (Age*0.0760766)+1.996217*(parity: nulliparity = 1, multiparity = 0) + 0.0021692*(MWD) + 0.8940321*(EFW/MH ration) + (-2.309326*(FBPD/MH ratio)) + (0.3593595*FHC/MH ratio)+ (-0.2086456*FAC/MH ratio) +(-1.265261*(FFL/MH ratio)) + (-0.4003198*GDM: Yes = 1, No= 0) + (0.7847241*No GDM screening: Yes= 1, No=0)+(2.42365*fetal position : OP= 1, OA = 0)

Abbreviations: MWD : maternal weight at delivery, GAB: gestational age at birth, MH : maternal height, EFW : estimated fetal weight, FBPD : fetal biparietal diameter, FHC : fetal head circumference, FAC : fetal abdominal circumference, FFL : fetal femur length, GDM : gestational diabetes mellitus, OP : occipito posterior position of fetus, OR : odds ratio

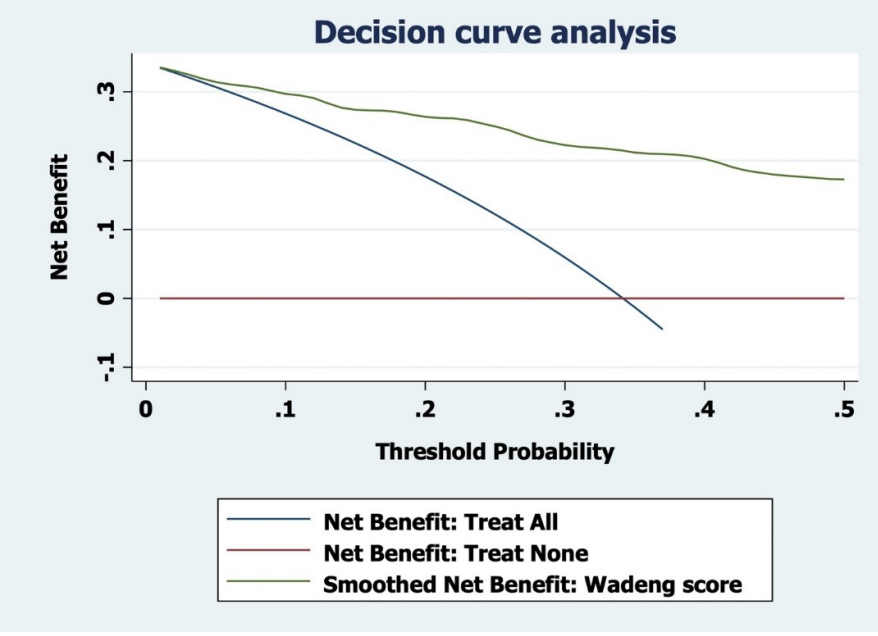
method (800 sampling times). The predictive model showed excellent internal validation according to the calibration plot as shown in Fig 3. It represented the agreement of predictive model probability. The decision-curve analysis demonstrated the clinical utility of the model as shown in Fig 4.

In order to use the model, the clinical setting was divided into three groups, namely: low (<0.32), intermediate (0.32-0.72) and high risk (>0.72). The score from the prediction model at 0.32 gave the likelihood ratio (LR) for cesarean delivery at 1. However, the score of 0.72 gave LR for cesarean delivery at 10-fold as shown in Fig 5 and Table 4. The enhanced predictive model could be accessed through this web link: https://wadeng-score.vercel.app/ or QR code as shown in Fig 5.



The result of internal validation was used by the Bootstrap method (800 sampling times). X axis represented the predictive of cesarean delivery by model. Y axis represented the real cesarean delivery.
The predictive model showed excellent internal validation according the calibration plot.

Fig 3. Calibration plot of expected and true cesarean delivery prediction



Decision curve for prediction model from 243 parturient in the current study.
Line A represented the condition of no treatment and net benefit is zero.
Line B represented the condition of treatment for 100 percent of cesarean delivery.
Line C represented the effect of treatment according to the presenting model.
The presenting model give the expected net benefit than no model used.

Fig 4. Decision curve analysis of the presenting model

TABLE 3. Comparison prediction model for labor dystocia from previous study and our study.

	YunSeok	Yanqing	Present
Years	2022	2023	2024
Country	Korea	China	Thailand
Designs	Retro	Retro	Retro
N	1,326	2,161	243
Stage of labor	Latent and active	Active	Latent
Characteristic			
Age	29.4	26.6	28.9
Nulliparity (%)	31.8	50	51
MH	160.34	No data	158
BMI	26.28	26.39	29.1
CDLD (%)	14.2	8.5	4.47
GA	39.5	42.9	38.8
Factor			
Age	✓		✓
MW			✓
Parity	✓		✓
GA	✓		
GDM			✓
CD	✓		
MS	✓		
PROM		✓	
Oxytocin use	✓		
PLT		✓	
Fetal position		✓	✓
Fetal station		✓	
EFW	✓		
FAC		✓	
EFW/MH			✓
FBPD/MH			✓
FHC/MH			✓
FAC/MH			✓
FFL/MH			✓
ROC	0.859	0.942	0.905
Cutoff	0.1	12.9	0.23
Sensitivity	85.19	84.2	91.6
Specificity	66.58	92.9	74.4
LR+	2.55		3.57
LR-	0.2		0.11

Abbreviations: MW: maternal weight, MH: maternal height, CDLD: primary cesarean rate due to labor dystocia, GA: gestational age, CD: cervical dilatation, MS: meconium staining, PROM: premature rupture of membrane, PLT: prolong latent phase, EFW: estimated fetal weight, FBPD: fetal biparietal diameter, FHC: fetal head circumference, FAC: fetal abdominal circumference, FFL: fetal femur length, PLP: prolong latent phase

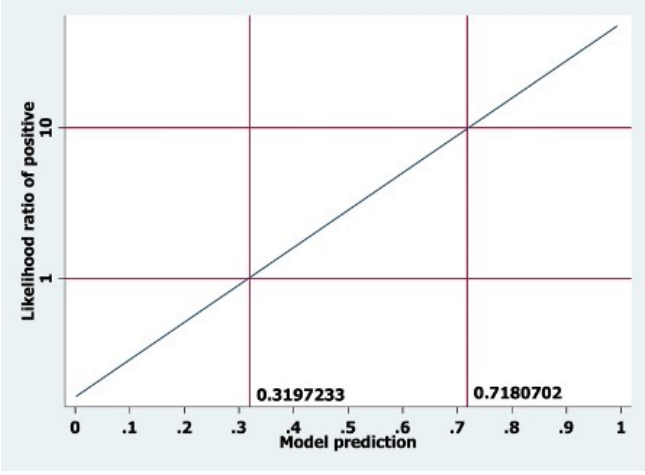


Fig 5. shown likelihood ratio (LR) with predictive score and QR code to access the predictive model using the Wadeng score.

TABLE 4. Distribution of CD due to LD in different level risk categories (low-, intermediate-, and high- risk)

	Score	Prevalence (%)	LR+	95% CI	*p*-value
Low	<0.32	11.33	0.25	0.16-0.38	<0.001
Intermediate	0.32-0.72	51.11	2.02	1.20-3.39	0.007
High	>0.72	89.58	16.58	6.83-40.30	<0.001

Abbreviations: CD: cesarean delivery, LD: labor dystocia, LR+: positive likelihood ratio, 95%CI: 95% Confidence Interval

DISCUSSION

CD is one of the most common obstetric operations performed worldwide.[11] Current estimates indicate that the global cesarean section rate is approximately 21%, with projections suggesting it will rise to 30% by 2030.[12] One of the indications of CD is LD.[1] LD is not currently used as a diagnostic tool. It requires integration of maternal and fetal evaluation, labor progression and expertise of obstetricians attending the patient.[2,13]

In this study, the correlation between FBP/MH ratio and cesarean delivery due to labor dystocia was evaluated. The FBP/MH ratios: EFW/MH, FBPD/MH, FHC/MH, FAC/MH and FFL/MH were shown as significant independent risk factors for CDLD. Furthermore, a new risk-prediction model named Wadeng score was proposed to estimate the risk of CDLD based on maternal risk factors and fetal sonographic parameters.

Comparison between Previous Model and Our Study

According to Table 3, in 2022 YunSeok presented a prediction model for CDLD. Their model consisted of parity, GA, MH, cervical dilatation, meconium staining, and the use of oxytocin and estimated fetal weight.[14] The Cesarean rate of YunSeok's study was only 14.2 percent. The AUC of the YunSeok model reported 0.859 levels. A suggested cut point from YunSeok study gave sensitivity, specificity, negative likelihood ratio (LR-) and positive likelihood ratio (LR+) of 85.2 percent, 66.6 percent, 0.2 and 2.5, respectively.[14] Yanqing from China reported their model for CDLD prediction in 2023. The Yanqing model consisted of premature rupture of membranes, FAC, prolonged latent phase, fetal station, and fetal position.[15] The Cesarean rate of Yanqing's study was 8.5 percent. AUC of the Yanqing model reported a level of 0.942. Sensitivity and specificity were reported at 84.2 and 92.9 percent, respectively.[15]

The current study incorporated 10 factors including age, parity, MWD, FPM/MH ratio, GDM and fetal position. The predictive model of the current study gave AUC a level of 0.905. Sensitivity, specificity, LR+ and LR- were recorded at 91.6%, 74.4%, 3.57, and 0.11, respectively. The current model gave more sensitivity and LR+ than YunSeok's model (91.6 vs 85.2 percent and 3.57 vs 2.5).

The AUC of current study slightly less than Yanqing's study (0.905 vs 0.942). However, the sensitivity of the current study exceeded Yanqing's report (91.6 vs 84.2 percent) which offers value as a screening tool.

The primary cesarean rates due to labor dystocia in our study, YunSeok's and Yanqing's studies, were 4.47, 14.2, and 8.5 percent, respectively. The possible explanation of low cesarean rates in the current study may be attributed to the strict adherence to ACOG and SMFM diagnostic criteria for labor dystocia by the staff on duty in the delivery room. As a result, cases of labor dystocia were less frequently diagnosed, with most cesarean sections performed for other conditions, such as failed induction.

The predictive value for CDLD from the current study had the same power as YunSeok's and Yanqing's studies. The web-based tool for the health care worker attending the labor room was used for its convenience and ease of use. The application was appropriate for use with parturients in latent phase. Yanqing's was appropriate for use with patients in active phase.[15] YunSeok and Yanqing used EFW and FAC from ultrasonography to generate predictive model, respectively. The Wadeng predictive model used more parameters than YunSeok and Yanqing (EFW/MH, FBPD/MH, FHC/MH, FAC/MH and FFL/MH ratio). The current predictive model was user-friendly for labor-attending personel in Thailand. Smartphone was electronic device that available in Thailand. It could be the easy screening tool to consider and consult to expertise obstetricians or refer to the well-equipped hospital.

Strengths and weakness

Our study developed an application to ensure convenient access and ease of use for labor attending personnel. This application was suitable for physicians who had limited expertise in assessing LD. Furthermore, the application from the current study categorized patients into three groups, namely: low, intermediate, and high risk for the purposes of management and referral planning. Lack of external validation and single center might be the limitations of the study.

Additional study including multicentric collaboration and larger sample sizes with external validation is suggested for future investigation to assess the predictive model's performance in diverse settings.

CONCLUSION

The Wadeng model was proposed. FBP/MH ratio was an independent risk factor for predicting CDLD. The Wadeng predictive model could be assessed via internet route by computer devices. Low, intermediate and high risk groupings from the predictive model gave the predictive value of CDLD risk at 0.25, 3.4 and 16.6 folds, respectively. A patient labeled as high-risk from the use of this predictive model might trigger the labor attending personnel to consult an expert obstetrician quite early, or the patient might be referred to a higher tier health center if the current facility has limited resources for future operation requirements. The relatively small sample size and lack of external validation were the limitation of the current study. External validation or integration into clinical practice would be the next step.

Data Availability Statement

Data about individual identified samples of this research will be available from the corresponding author Wanlaya Onwatanasrikul upon reasonable request after the main results of the research have been published.

ACKNOWLEDGMENTS

This study was supported by the Bhumibol Adulyadej Hospital Research Fund granted in 2024. The authors thank Buppa Smanchat, Chaipat Winyoovijit for excellent consulting.

DECLARATION

Grants and Funding Information

This research has been funded by the Bhumibol Adulyadej Hospital Fund (Funding No. 154/68).

Conflict of Interest

The authors declare that they have no competing interests in this work.

Registration Number of Clinical Trial

None.

Author Contributions

Conceptualization and methodology, W.W., W.O., N.K., M.P. and S.P. ; Investigation, W.W; Formal analysis, W.W., W.O., N.K., M.P. and S.P. ; Visualization and writing – original draft, W.W., W.O., K.B. and K.S.M.; Writing – review and editing, W.W., W.O., M.P., K.B. and K.S.; Supervision, W.O. and K.S. All authors have read and agreed to the final version of the manuscript.

Use of Artificial Intelligence

No content was generated using AI.

REFERENCES

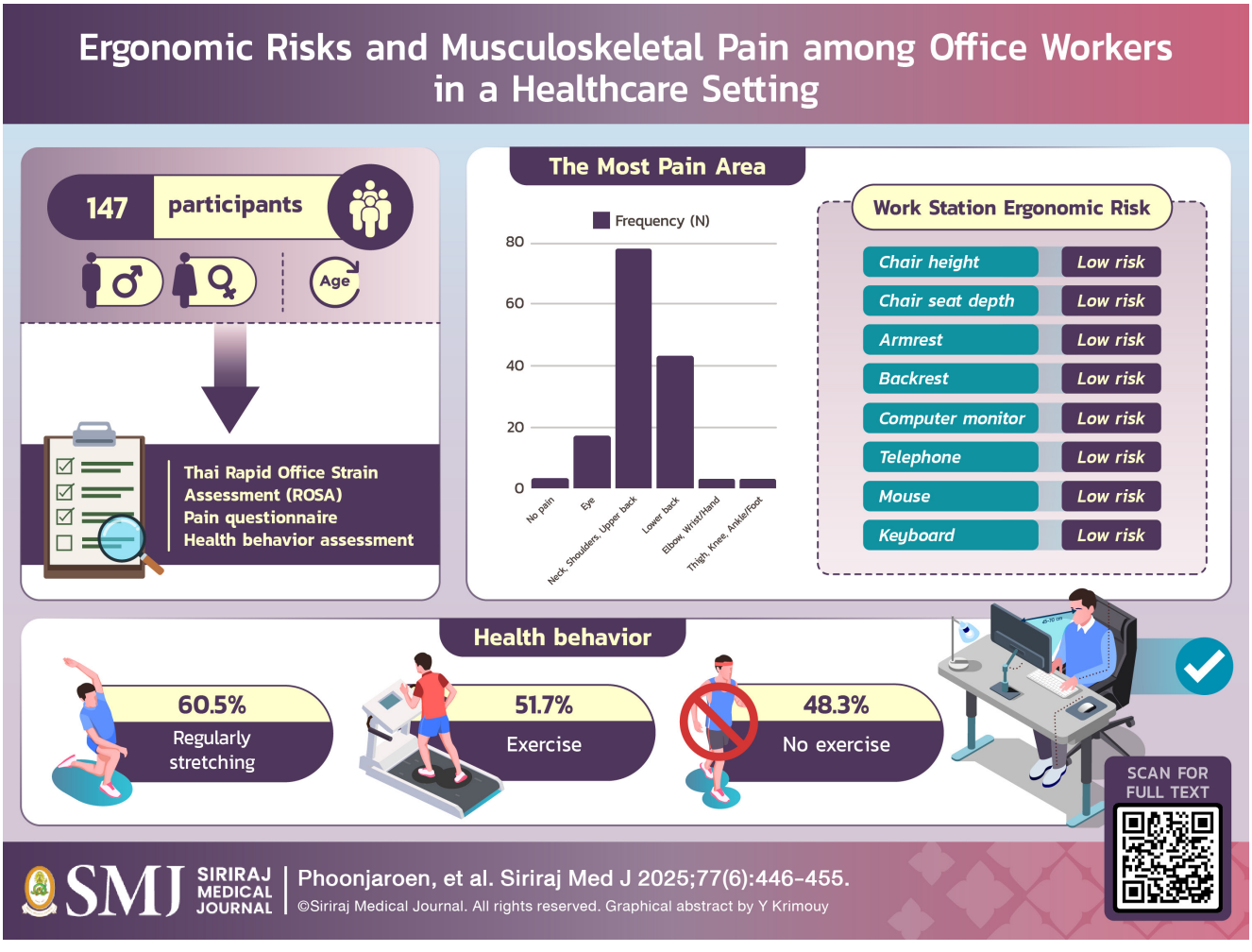
1. Cunningham FG, Lenovo JK. Physiology of Labor. In: Cunningham FG, Lenovo JK, editors. Williams Obstetrics. 26th ed. New York: McGraw Hill Education; 2022.p.27-30, 398-443.
2. Titapant V, Phtithakwatchara N. Trends in Modes of Delivery in Siriraj Hospital. Siriraj Med J. 2007;59:271-3.
3. Lerkovit S, Camann WR. Effective Epidural Analgesia during Labor: A Feasible Method to Decrease Unnecessary Cesarean Deliveries in Thailand. Siriraj Med J. 2024;76:541-9.
4. Di Pasquo E, Morganelli G, Volpe N, Labadini C, Ramirez Zegarra R, Abou-Dakn M, et al. The sonographic measurement of the ratio between the fetal head circumference and the obstetrical conjugate is accurate in predicting the risk of labor arrest: results from a multicenter prospective study. Am J Obstet Gynecol MFM. 2022;4(6):100710.
5. Molaei B, Ghafoori S, Manteghi G, Tofighi Sh. Fetal Weight and Head Circumference Estimated by Ultrasound for Predicting Cervical Dilatation Progression Rate and Mode of Delivery. J Midwifery Reprod Health. 2022;10(4):3516-22.
6. Lipschuetz M, Cohen SM, Israel A, Baron J, Porat S, Valsky DV, et al. Sonographic large fetal head circumference and risk of cesarean delivery. Am J Obstet Gynecol. 2018;218(3):339.e1-7.
7. Verhoeven CJ, Rückert ME, Opmeer BC, Pajkrt E, Mol BW. Ultrasonographic fetal head position to predict mode of delivery: a systematic review and bivariate meta-analysis. Ultrasound Obstet Gynecol. 2012;40(1):9-13.
8. Dall'Asta A, Ramirez Zegarra R, Corno E, Mappa I, Lu JLA, Di Pasquo E, et al. Role of fetal head-circumference-to-maternal-height ratio in predicting Cesarean section for labor dystocia: prospective multicenter study. Ultrasound Obstet Gynecol. 2023;61(1):93-8.
9. Caughey AB, Cahill AG, Guise J-M, Rouse DJ. Safe prevention of the primary cesarean delivery. Am J Obstet Gynecol. 2014;210:179-93.
10. Zhang J, Landy HJ, Ware Branch D, Burkman R, Habermann S, Gregory KD, et al. Consortium on Safe Labor. Contemporary patterns of spontaneous labor with normal neonatal outcome. Obstet Gynecol. 2010;116(6):1281-7.
11. Boatin AA, Ngonzi J, Ganyaglo G, Mbaye M, Wylie BJ, Diouf K. Cesarean delivery in low- and middle-income countries: A review of quality of care metrics and targets for improvement. Semin Fetal Neonatal Med. 2021;26(1):101199.
12. Betran AP, Ye J, Moller AB, Souza JP, Zhang J. Trends and projections of caesarean section rates. global and regional estimates. BMJ Glob Health. 2021;6(6):e005671.
13. Sunsaneevitayakul P, Sompagdee N, Asad-Dehghan M, Talungchit P. Effect of Gestational Weight Gain on Overweight and Obese Pregnant Women. Siriraj Med J. 2022;74:364-70.
14. Yang Y. An intrapartum calculator for predicting cesarean birth due to dystocia: Preliminary findings from a single-center study in Korea. Birth. 2022;49(4):628-36.
15. Liu Y, Gong Q, Yuan Y, Shi Q. Prediction model for labour dystocia occurring in the active phase. J Obstet Gynaecol. 2023;43(1):2174837.

Ergonomic Risks and Musculoskeletal Pain among Office Workers in a Healthcare Setting: A Cross-Sectional Study

Prawit Phoonjaroen, B.Sc.[1], Nitchakan Utaiwattana, B.Sc.[1], Chirathip Thawisuk, M.Sc.[2,*]

[1]Occupational Therapy Division, Golden Jubilee Medical Center, Faculty of Medicine Siriraj Hospital, Mahidol University, Nakhon Pathom, Thailand,

[2]Department of Occupational Therapy, Faculty of Associated Medical Sciences, Chiang Mai University, Chiang Mai, Thailand.



*Corresponding author: Chirathip Thawisuk
E-mail: chirathip.t@cmu.ac.th
Received 11 November 2024 Revised 21 January 2025 Accepted 22 January 2025
ORCID ID: http://orcid.org/0000-0001-7650-617X
https://doi.org/10.33192/smj.v77i6.272161

ABSTRACT

Objective: The primary aim of this study is to assess ergonomic risks among office workers at the Golden Jubilee Medical Center using the Rapid Office Strain Assessment Thai version (Thai ROSA). Additionally, the study explores the relationship between ergonomic risks and pain, considering the multifaceted nature of work-related discomfort.

Materials and Methods: A cross-sectional study was conducted, involving 147 office workers who regularly use desktop computers. The Thai ROSA tool was employed for ergonomic risk assessment. Self-report questionnaires, including a pain questionnaire and health behavior assessment, were utilized. Statistical analyses, including descriptive statistics and bivariate analyses, were applied to interpret the data.

Results: While the majority of participants reported low ergonomic risk, the prevalence of musculoskeletal pain, particularly in the neck and lower back, was noteworthy. Surprisingly, discrepancies were observed between Thai ROSA-assessed ergonomic risks and reported pain levels.

Conclusion: The study highlights the pervasive issue of musculoskeletal pain among office workers, urging comprehensive strategies beyond conventional ergonomic assessments. Despite low Thai ROSA-assessed risks, a substantial portion reported discomfort, emphasizing the need for refined ergonomic tools and workplace interventions. Encouraging healthy behaviors is crucial for overall well-being, and future research should explore the intricate interplay between physical and mental factors contributing to work-related pain.

Keywords: Work-related musculoskeletal disorders; ergonomics; rapid office strain assessment (Siriraj Med J 2025; 77: 446-455)

INTRODUCTION

In the modern era, desktop and portable computers have become essential tools in the office, enabling efficient task completion and time savings.[1] Many office workers rely on computers as their primary work tool, with work durations often exceeding four hours per day.[2] Despite the common perception that office work may not require substantial physical exertion, it can lead to Work-Related Musculoskeletal Disorders (WMSDs), often resulting from poor posture.[3] Prolonged periods of maintaining the same posture, such as sitting at a computer with the head inclined toward the screen and fingers and wrists held in static positions, can adversely affect muscles, ligaments, joints, and bones, increasing the risk of injury.[4,5] Risk factors for WMSDs can be categorized into three main groups: physical, psychosocial, and personal factors.[6,7] Physical factors include repetitive tasks, prolonged static positions, joint pressure, and significant physical effort. Psychosocial factors include motivation to work, time constraints, and stress, while personal factors include age, gender, body proportions, and daily life activities.[6,7] The impact of WMSDs extends beyond individual discomfort, significantly impacting work performance and overall quality of life.[8] These conditions often require medical attention, diverting time and resources away from work and ultimately affecting organizational productivity.

Ergonomics, the discipline of human interactions within occupational contexts across various dimensions[9], is a crucial discipline that focuses on addressing ergonomic risks faced by office workers. It specifically focuses on office environments, and ergonomic principles involve optimizing working conditions by considering the positioning and utilization of office equipment directly linked to tasks.[10] Applying ergonomic principles in the office not only prevents WMSDs but also enhances comfort and efficiency, reducing the risk of injury.[11] To effectively assess and address ergonomic risks, it is essential to identify and prioritize high-risk factors in the workplace.[11] Various assessment tools have been developed to assess ergonomic risks, each tailored to the nature of work being performed. For instance, the Rapid Upper Limb Assessment (RULA) is commonly employed for manual tasks, while the Rapid Office Strain Assessment (ROSA) is designed to identify ergonomic risks associated with desktop computer use.[12] In Thailand, ROSA is used to evaluate ergonomic risks in office settings.[13] Previous research has shown that hospital staff face ergonomic risks related to computer use, with almost all participants experiencing discomfort in at least one area due to poor posture, particularly in the neck, lower back, and upper back. The surveyed postures were found to pose medium to high ergonomic risks, with administrative staff exhibiting the highest frequency of risky postures. Although most of these risks were linked to sitting, a significant portion of computer-related postures were also found to be non-ergonomic.[14] However, studies using Thai ROSA to assess ergonomics risks among healthcare workers in Thai hospital settings remain scarce.

Occupational therapists play a pivotal role in preventing work-related injuries by applying ergonomics to support workplace health through analyzing work, work activities and styles, making environmental adjustments, and conducting physical assessments.[15,16] The ROSA, an efficient, evidence-based tool, offers a comprehensive evaluation of both the individual and their work environment, making it particularly suitable for bustling hospital settings in Thailand where quick identification of musculoskeletal disorders are essential. The ROSA outcomes provide actionable insights, guiding interventions that reduce strain and injury risk and align with the holistic approach of occupational therapy. Therefore, ROSA stands out as a practical tool for studying ergonomic risks among healthcare workers. This research aimed to study ergonomic risks among office workers using desktop computers through Thai ROSA and to explore the relationship between ergonomic risks and pain in these workers.

MATERIALS AND METHODS

Study design

A cross-sectional study was conducted to assess ergonomic risk factors among office workers at the Golden Jubilee Medical Center. This design allowed for the simultaneous collection of data on ergonomic factors and participants' health status at a single time point.[17] The study was carried out at the Golden Jubilee Medical Center and involved various office spaces in the facility, with participants recruited from different departments, such as administrative offices, medical records, and other divisions.

Participants

The study population consisted of office employees at the Golden Jubilee Medical Center, Thailand, who use desktop computers. As of October 2022, the center had 237 employees, according to the human resources division. The sample size was determined based on a study by *Krusun and Chaiklieng* (2017)[18], which evaluated ergonomic risks among university office employees in northeastern Thailand using the ROSA assessment. The study found that 66.23% of office workers faced high ergonomic risk from computer use, while 19.48% faced moderate risk. Based on these findings, the researchers estimated that 60% of computer users would face high ergonomic risk. With a 5% acceptable error level and a 95% confidence level, the required sample size was estimated to be 147 participants using G-power calculations. The sample group was divided into two departments, comprising 24 divisions, in line with the hospital's structure. Proportional stratified sampling was used to select representative office employees from each division.

Inclusion Criteria

1. Full-time office employees of the Golden Jubilee Medical Center with a minimum continuous employment period of six months.
2. Regularly perform work-related tasks using a desktop computer as their primary workstation.
3. Use a desktop computer for at least four hours per workday on average during the past month.

Exclusion Criteria

1. Employees who use a desktop computer for less than four hours per workday.
2. Individuals diagnosed with musculoskeletal disorders due to congenital conditions, accidents, or other non-work-related causes (verified by medical records).
3. Individuals diagnosed with neurological disorders due to congenital conditions, genetic disorder, accidents, infections, or other non-work-related causes (verified by medical records).
4. Individuals diagnosed with psychological disorders includes those listed in DSM-5 and ICD-10, or other non-work-related causes (verified by medical records).
5. Employees undergoing treatment (e.g., physical therapy) for musculoskeletal conditions during the study period.
6. Employees with prior ergonomic interventions or modifications at their workplace related to the study objectives.

The study protocol was approved by the institutional IRB (number: Si 298/2023). Informed consent was obtained from all participants before data collection. Confidentiality and anonymity were ensured throughout the study.

Measurements

Self-report questionnaire

This questionnaire was developed by researchers and comprises two parts: (1) demographic information and pain questionnaire (Numeric Rating Scale: NRS), and (2) health behavior questionnaire. The NRS evaluates pain on a scale from 0 to 10, where 0 indicates no pain and 10 indicates the worst pain imaginable. For the purposes of categorizing pain levels, scores ≤5 indicate mild pain, scores of 6–7 represent moderate pain, and scores ≥8 signify severe pain.[19]

ROSA Thai version[13]

The Thai version of the ROSA's scoring is based on evaluating three main sections, including the chair (section A), screen and phone (section B), keyboard and mouse (section C).[20] Risk factors were scored according

to each subsection. Each subsection has a scoring chart, and a corresponding value due to the combination of partitions. Within section A, factors like armrests, back support, and seat pan height/depth were calculated to compose the horizontal and vertical axes of the chart, respectively. Then, chart values for sections B and C were combined into another chart, resulting in monitor and peripheral scores. In the final chart, chair, screen, and peripheral scores (A, B and C) are combined for risk classification.[20] The final ROSA score ranged from 1 to 10, with a higher score indicating a greater risk of musculoskeletal disorders. A score of five or more suggests an immediate need for intervention.[13,20] This assessment is designed as an observation tool and further validated for use as a self-assessment by office workers.[21] The ROSA Thai version used in this research was translated according to international standards, had universal agreement calculation method (S-CVI/UA) = 0.80, scale-level content validity index (S-CVI/Ave) = 0.95 and very high inter- and intra-rater reliability values, with inter-rater ICC = 0.99 and intra-rater ICC = 0.91.[13]

Data collection

After explaining the research objectives to the employees and obtaining their written consent to participate in the study, the self-report questionnaire, along with the Thai version of ROSA, which included detailed instructions for recording data and providing contact information for the researcher, was distributed to participants for self-completion. Additionally, trained assessors were available to clarify questions and ensure proper understanding of the instructions during data collection. This research was performed in accordance with the ethical standards of the Declaration of Helsinki.

Statistical analysis

Descriptive statistics were used to summarize demographic characteristics, pain areas and levels, health behaviors, and ergonomic risk levels. Bivariate analyses, including Fisher's exact test and Chi-squared test, were conducted to examine the relationship between ergonomic risk factors and pain among office workers using desktop computers.

RESULTS

Demographic data

A total of 147 participants completed the questionnaire, with the majority being female (n=112, 76.2%) and the remainder male (n=35). The predominant age group was 31-41 years old (n=70), followed by participants aged 30 or younger (n=38). In terms of health conditions, 78.2% of participants reported having no medical issues (n=115). Most participants had a normal body mass index (BMI) according to the Asia-Pacific classification[22], with 68 individuals falling within the range of 18.5-22.9. However, 38 participants had a BMI over 25.0, indicating obesity. Regarding computer usage, over 80% of participants spent 4-8 hours working on computers (n=118), with 19.7% dedicating more than 9 hours to computer-related activities (n=29). Additional details can be found in Table 1.

Pain

The areas with the highest discomfort were the neck, shoulder, and upper back 53.1% (n=78), followed by the lower back 29.3% (n=43) and eyes 11.6% (n=17). The average pain level was 6.37 ± 1.68. Specifically, the average pain level for the neck, shoulder, and upper back was 5.72 ± 2.15, while for the eye area, it was 4.88 ± 2.18 (Table 2). Notably, the lower back reported the highest average pain level. Among participants reporting the highest pain levels in the neck, shoulder, upper back, and eye areas (a total of 138 cases), 97 cases (70.3%) described pain as a slight obstacle to work, while in 23 cases (16.7%), it did not hinder work. Additionally, for sleep, 80 cases (58.0%) reported pain as a slight obstacle to sleeping, while in 36 cases (26.1%), it did not affect sleep (Table 3).

Health behavior

Regarding health behaviors of the participants, the majority performed muscle stretching during work, accounting for 89 participants (60.5%). There were 76 participants (51.7) who exercised, with most exercising 1-2 days per week 52 participants (35.4%), followed by those exercising 3-5 days per week, 20 participants (13.6%). The most common type of exercise was running, 29 participants (19.7%), followed by playing sports, 20 participants (13.6%), as shown in Table 4.

Ergonomics risks

An assessment of the working conditions of office employees at the Golden Jubilee Medical Center using the Thai ROSA tool revealed that all employees fell into the low-risk category. The computer screen presented the highest risk factor, with an average score of 2.20 ± 0.91, followed by mouse usage with an average score of 2.01 ± 1.02. Keyboard usage had a lower average risk factor assessment score of 1.80 ± 0.90, as indicated in Table 5.

TABLE 1. Demographic data (n=147).

General information	n (%)
Sex	
Male	35 (23.8)
Female	112 (76.2)
Age (years)	
≤ 30	38 (25.9)
31-41	70 (47.6)
41-50	35 (23.8)
> 50	4 (2.7)
Medical conditions	
Do not have	115 (78.2)
Have	32 (21.8)
Body mass index (kg/m²)	
Under-weight (<18.5)	9 (6.1)
Normal (18.5-22.9)	68 (46.3)
Over-weight (23.0-24.9)	32 (21.8)
Obese (>25.0)	38 (25.9)
Time spent working on the computer per day at work (hours)	
4-8	118 (80.3)
≥ 9	29 (19.7)
Devices used on Social Media outside of work hours	
Desktop computer (PC)	4 (2.7)
Portable computer (Notebook / Laptop)	6 (4.1)
Smart phone (SmartPhone)	126 (85.7)
Tablet (Tablet/ iPad /Galaxy Tab)	11 (7.5)
Time spent on Social Media outside of work (hours)	
≤ 1	16 (10.9)
2-3	91 (61.9)
≥ 4	40 (27.2)

TABLE 2. Information about pain (n=147).

Pain area	n (%)	Pain score (Mean ± SD.)
No pain	3 (2.0)	-
Eye	17 (11.6)	4.88 ± 2.18
Neck, shoulders, upper back	78 (53.1)	5.72 ± 2.15
Lower back	43 (29.3)	6.37 ± 1.68
Elbow, wrist/hand	3 (2.0)	2.33 ± 1.76
Thigh, knee, ankle/foot	3 (2.0)	3.11 ± 1.95

TABLE 3. Information about pain and areas of pain (n=138).

	Neck, shoulders, upper back (n=78) n (%)	Lower back (n=43) n (%)	Eye (n=17) n (%)	Total (n=138) n (%)
Duration of pain (months)				
≤ 3	36 (46.2)	15 (34.9)	12 (70.6)	63 (45.7)
4-6	18 (23.1)	12 (27.9)	4 (23.5)	34 (24.6)
7-9	7 (9.0)	4 (9.3)	1 (5.9)	12 (8.7)
10-12	2 (2.6)	2 (4.7)	0	4 (2.9)
≥ 12	15 (19.2)	10 (23.3)	0	25 (18.1)
Pain is a hindrance to work				
Not at all	13 (16.7)	5 (11.6)	5 (29.4)	23 (16.7)
A little	51 (65.4)	35 (81.4)	11 (64.7)	97 (70.3)
A lot	14 (17.9)	3 (7.0)	1 (5.9)	18 (13.0)
Pain is an obstacle to sleeping				
Not at all	19 (24.4)	11 (25.6)	6 (35.3)	36 (26.1)
A little	44 (56.4)	26 (60.5)	10 (58.8)	80 (58.0)
A lot	15 (19.2)	6 (14.0)	1 (5.9)	22 (15.9)
The pain caused me to take time off from work				
No	70 (89.7)	40 (93.0)	16 (94.1)	126 (91.3)
Yes	8 (10.3)	3 (7.0)	1 (5.9)	12 (8.7)

TABLE 4. Information about health behavior of the participant (n=147).

Health behavior	n (%)
Muscle stretching during work (n=147)	
No	58 (39.5)
Yes	89 (60.5)
Do you do any exercise (n=147)	
No	71 (48.3)
Yes	76 (51.7)
How often do you exercise (days per week) (n=76)	
1-2	52 (35.4)
3-5	20 (13.6)
> 5	4 (2.7)
Type of exercise (n=76)	
Aerobic exercise	5 (3.4)
Running	29 (19.7)
Yoga	8 (5.4)
Weight training	7 (4.8)
Fitness	7 (4.8)
Playing Sports	20 (13.6)

TABLE 5. Assessment of the working environment of office employees at the Golden Jubilee Medical Center By Thai ROSA (n=147).

Working environment	Risk factor assessment score (Mean ± SD.)	Risk level
Chair height	1.48 ± 0.71	Low level of risk
Chair seat depth	1.51 ± 0.64	Low level of risk
Armrest	1.44 ± 0.82	Low level of risk
Backrest	1.58 ± 0.71	Low level of risk
Computer monitor	2.20 ± 0.91	Low level of risk
Telephone	1.22 ± 1.03	Low level of risk
Mouse	2.01 ± 1.02	Low level of risk
Keyboard	1.80 ± 0.90	Low level of risk

Relationships between ergonomic risks and pain

The analysis explored the connection between maximal pain level of each participant and body posture assessments in an office work setting. The Thai ROSA assessment revealed no significant relationship between ergonomic risks and reported pain levels. Out of 147 office employees at the Golden Jubilee Medical Center, 119 participants met the ergonomic low risk criteria (Final score <5)[13], while 28 did not, as indicated in Table 6.

DISCUSSION

Musculoskeletal pain is highly prevalent among office workers, yet the relationship between ergonomic risks assessed by the Thai ROSA and self-reported pain remains unclear. This study found that although ROSA classified all participants as low-risk for ergonomic issues, 29.3% reported low back pain, with the maximal pain level score of 6.37 ± 1.68, categorized as moderate pain.[19] This discrepancy highlights the limitations of static ergonomic assessments, which may not account for dynamic interactions between workers and their environments.[20] For instance, compensatory behaviors such as slouching or leaning forward during prolonged tasks are not captured by ROSA, despite their significant role in contributing to musculoskeletal strain.[23]

Unlike previous studies that reported stronger correlations between ergonomic risk scores and pain[24-26], our findings suggest that these relationships may depend on additional factors such as psychosocial stressors and individual behaviors. Methodological differences, such as broader inclusion of psychosocial dimensions in other studies, may also account for this divergence.[24-27] For example, high psychological stress or multitasking demands, often unmeasured by static assessments, may exacerbate pain perception, further complicating the ergonomic risk-pain relationship.[28]

TABLE 6. Relationship between pain level and Rapid Office Strain Assessment (ROSA) final score.

	Rapid Office Strain Assessment (ROSA Final Score)		
	Low risk (n=119)	High risk (n=28)	P - value
Maximal pain level of each participant	5.6 ± 2.3	5.3 ± 2.0	0.512

Additionally, this study observed a 19% ergonomic non-compliance rate, despite low-risk ROSA scores. This suggests that barriers such as limited ergonomic training[29,30], lack of awareness[29,30], or organizational constraints—like insufficient resources or time for adjustments[29,31]—continue to challenge the implementation of effective ergonomic practices. Addressing these gaps requires workplace interventions that prioritize regular training, tailored workstation adjustments, and ongoing ergonomic evaluations.

In this study, participants reported moderate discomfort, predominantly in the neck, shoulders, upper back, and lower back, with lower back pain being the most intense. Despite this, most participants indicated minimal interference with work and sleep, suggesting a degree of adaptation or tolerance. Interestingly, the areas most affected by pain align with the high levels of smartphone usage reported, with 61.9% of participants spending 2-3 hours daily on social media. This aligns with prior research linking prolonged digital device use to neck and upper back discomfort[32,33], emphasizing the importance of ergonomic strategies for mitigating screen-related strain.

While over half of the participants engaged in health-promoting behaviors such as stretching or exercise, the study did not explore the relationship between these activities and pain levels. However, consistent with prior research, such behaviors likely alleviate musculoskeletal strain by improving flexibility, muscle strength, and circulation.[34,35] The effectiveness of these practices depends on their frequency and consistency[36], suggesting a need for structured workplace programs that integrate regular physical activity[37], such as micro-breaks, guided exercises[38], or standing desks, to counteract prolonged static postures.[39]

This study also highlights the limitations of the Thai ROSA as a self-assessment tool. Sonne[21] demonstrated discrepancies between worker-reported and observer-reported ROSA scores, particularly for mouse and keyboard assessments, with workers often underestimating risk factors. Despite these limitations, self-assessment using tools like ROSA shows promise in helping workers identify and reduce risk factors for musculoskeletal discomfort over time.[21] However, static tools like ROSA do not account for dynamic workplace factors, such as posture variability, fatigue, or individual differences like height or pre-existing conditions. Future iterations of ergonomic tools should address these gaps by incorporating real-time posture tracking, psychosocial stress assessments, and modules for contextual factors such as lighting, noise, and workload demands.

Overall, this study underscores the complex interplay between physical, behavioral, and psychosocial factors contributing to workplace pain. Future research should aim to refine ergonomic assessment tools, explore alternative pain management strategies, and develop holistic interventions that address both physical and mental aspects of worker health.

CONCLUSION

Although this study did not establish a direct link between ROSA-assessed ergonomic risks and pain, it highlighted the widespread issue of pain among office workers. The findings emphasize that pain is multifaceted, extending beyond ergonomics. This calls for comprehensive strategies to improve workplace ergonomics, promote healthy behaviors like stretching and exercise, and address both physical and mental factors contributing to pain. A holistic approach to pain management is essential, focusing on both physical comfort and mental well-being to prevent work-related issues and safeguard workers' health.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy or ethical restrictions.

ACKNOWLEDGEMENTS

The authors are grateful to all the participants who participated in this study.

DECLARATIONS

Grant and Funding Information

This project is not funded by any external source.

Conflict of Interest

The authors declare that they have no competing interests.

Registration Number of Clinical Trial

Not applicable.

Author Contributions

Conceptualization and methodology, P.P., and N.U. ; Investigation, P.P., and N.U. ; Formal analysis, P.P, N.U., and C.T. ; Visualization and writing – original draft, P.P., and C.T. ; Writing – review and editing, P.P., N.U., and C.T. ; Supervision, C.T. All authors have read and agreed to the final version of the manuscript.

Use of Artificial Intelligence

The manuscript is not produced using artificial intelligence.

Human ethics approval declaration

This study was approved by the Siriraj Institutional Review Board, Bangkok, Thailand (IRB No. Si 298/2023).

REFERENCES

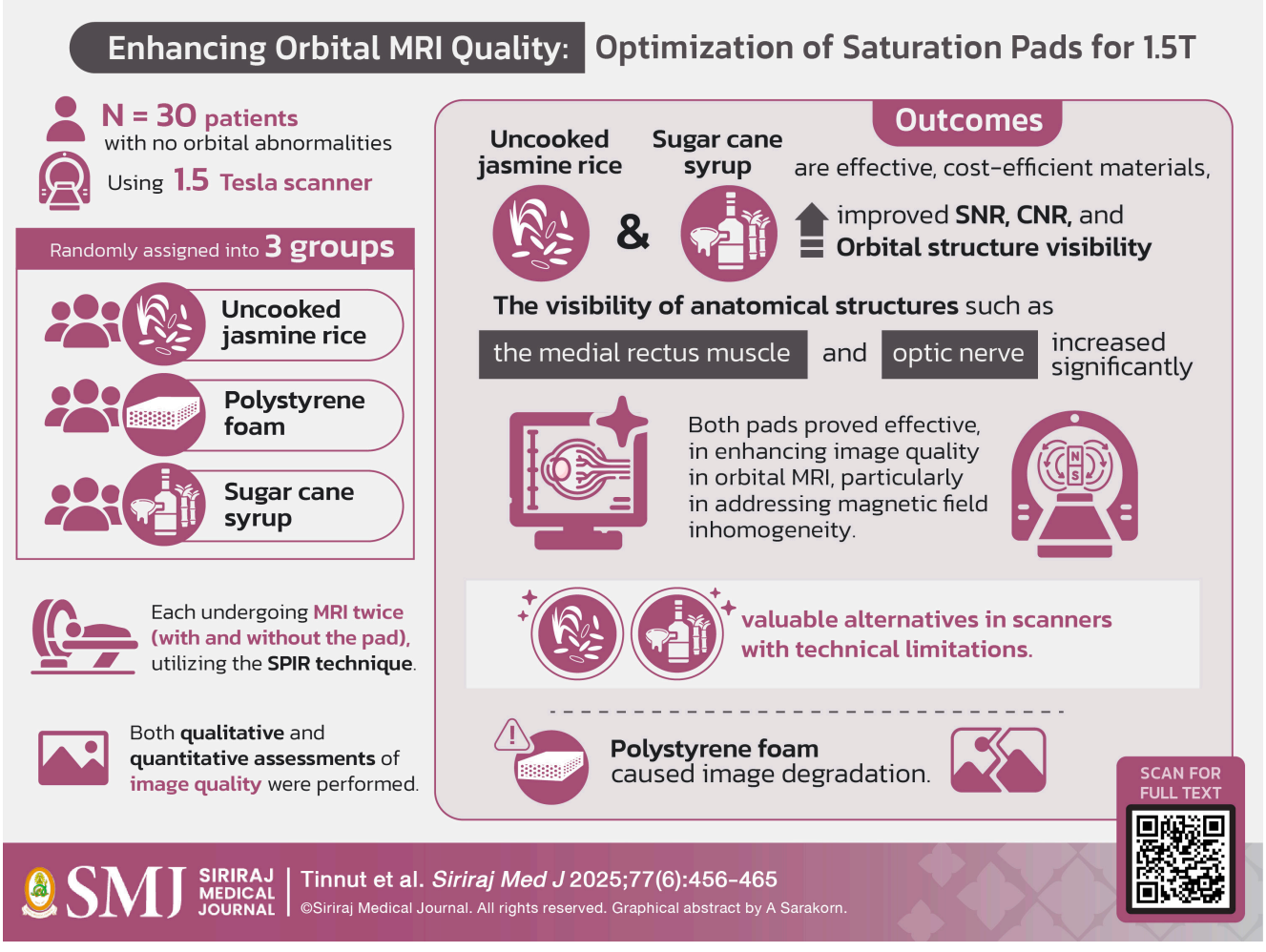
1. Beer P, Mulder RH. The Effects of technological developments on work and their implications for continuous vocational education and training: a systematic review. Front Psychol. 2020; 11:918.
2. Soonthornvinit W, Chaiear N, Boonjaraspinyo S, Tiamkao S. Working Hours Related to Good Quality of Work Life (QoWL) among Doctors Working in Public Hospitals in Northeastern Thailand. J Med Assoc Thai. 2019;102(Suppl 1):S47-S54.
3. Chinedu NOO, Henry NAT, Nene NJJ, Okwudili NJD. Work-Related Musculoskeletal Disorders among Office Workers in Higher Education Institutions: A Cross-Sectional Study. Ethiop J Health Sci. 2020;30(5):715-24.
4. Baker R, Coenen P, Howie E, Williamson A, Straker L. The short term musculoskeletal and cognitive effects of prolonged sitting during office computer work. Int J Environ Res Public Health. 2018;15(8):1678.
5. Jacquier-Bret J, Gorce P. Prevalence of Body Area Work-Related Musculoskeletal Disorders among Healthcare Professionals: A Systematic Review. Int J Environ Res Public Health. 2023;20(1):841.
6. Hush JM, Michaleff Z, Maher CG, Refshauge K. Individual, physical and psychological risk factors for neck pain in Australian office workers: a 1-year longitudinal study. Eur Spine J. 2009;18(10):1532-40.
7. Hernandez AM, Peterson AL. Work-Related musculoskeletal disorders and pain. In: Springer eBooks. 2012.p.63-85.
8. Chang YF, Yeh CM, Huang SL, Ho CC, Li RH, Wang WH, et al. Work Ability and Quality of Life in Patients with Work-Related Musculoskeletal Disorders. Int J Environ Res Public Health. 2020;17(9):3310.
9. Ghosh S, Bagchi A, Sen D, Bandyopadhyay P. Ergonomics: A bridge between fundamentals and applied research. Indian J Occup Environ Med. 2011;15(1):14-7.
10. Soares CO, Pereira BF, Gomes MVP, Marcondes LP, De Campos Gomes F, De Melo- Neto JS. Fatores de prevenção de distúrbios osteomusculares relacionados ao trabalho: revisão narrativa. Revista Brasileira De Medicina Do Trabalho. 2019;17(3): 415-30.
11. Jun D, Zoe M, Johnston V, O'Leary S. Physical risk factors for developing non-specific neck pain in office workers: a systematic review and meta-analysis. Int Arch Occup Environ Health. 2017;90(5):373-410.
12. Kittijaruwattana J, Ratcha M, Tuprakay S, Surach A. A Systematic Review: Using Trends of Ergonomic Risk Assessment Tools. Health Sci J Thai. 2023;5(4):49-58.
13. Kingkaew WM, Paileeklee S, Jaroenngarmsamer P. Validity and Reliability of the Rapid Office Strain Assessment [ROSA] Thai version. J Med Assoc Thai. 2018;101(1):145-9.
14. Kibria MG, Parvez MS, Saha P, Talapatra S. Evaluating the ergonomic deficiencies in computer workstations and investigating their correlation with reported musculoskeletal disorders and visual symptoms among computer users in Bangladeshi university. Heliyon. 2023;9(11):e22179.
15. Bade S, Eckert J. Occupational therapists' critical value in work rehabilitation and ergonomics. Work. 2008;31(1):101-11.
16. Gainer RD. History of ergonomics and occupational therapy. Work. 2008;31(1):5-9.
17. Setia MS. Methodology series module 3: Cross-sectional studies. Indian J Dermatol. 2016;61(3):261-4.
18. Krusun M, Chaiklieng S. Ergonomic risk assessment in university office workers. APST. 2017;19(5):696-707.
19. Boonstra AM, Stewart RE, Köke AJ, Oosterwijk RFA, Swaan JL, Schreurs KMG, et al. Cut-Off Points for Mild, Moderate, and Severe Pain on the Numeric Rating Scale for Pain in Patients with Chronic Musculoskeletal Pain: Variability and Influence of Sex and Catastrophizing. Front Psychol. 2016;7:1466.
20. Sonne M, Villalta DL, Andrews DM. Development and evaluation of an office ergonomic risk checklist: ROSA – Rapid office strain assessment. Appl Ergon. 2012;43(1):98-108.
21. Sonne M, Andrews DM. The Rapid Office Strain Assessment (Rosa): Validity of online worker self-assessments and the relationship to worker discomfort. Occupational Ergonomics. 2012;10(3):83-101.
22. World Health Organization. Regional Office for the Western Pacific. The Asia-Pacific perspective: redefining obesity and its treatment. Sydney: Health Communications Australia. 2000. Available from: https://iris.who.int/handle/10665/206936
23. Matos M, Arezes PM. Ergonomic evaluation of Office Workplaces with Rapid Office Strain Assessment (ROSA). Procedia Manufacturing. 2015;3:4689-94.
24. Chiasson MÈ, Imbeau D, Major J, Aubry K, Delisle A. Influence of musculoskeletal pain on workers' ergonomic risk-factor assessments. Appl Ergon. 2015;49:1-7.
25. Andersen LL, Vinstrup J, Sundstrup E, Skovlund SV, Villadsen E, Thorsen SV. Combined ergonomic exposures and development of musculoskeletal pain in the general working population: A prospective cohort study. Scand J Work Environ Health. 2021; 47(4):287-95.
26. Arvidsson I, Gremark Simonsen J, Lindegård-Andersson A, Björk J, Nordander C. The impact of occupational and personal factors on musculoskeletal pain - a cohort study of female nurses, sonographers and teachers. BMC Musculoskelet Disord. 2020;21(1):621.
27. Khanngern N, Ratta-apha W, Wannarit K. Burnout among Mental Health Professionals in a Tertiary University Hospital. Siriraj Med J. 2022;74(3):185-92.
28. Espin A, Núñez-Cortés R, Irazusta J, Rodriguez-Larrad A, Torres-Unda J, Vinstrup J, et al. Mental health and vitality predict spinal pain in healthcare workers. Occup Med (Lond). 2023;73(8):464-9.
29. van Eerd D, Cole D, Irvin E, Mahood Q, Keown K, Theberge N, et al. Process and implementation of participatory ergonomic interventions: a systematic review. Ergonomics. 2010;53(10): 1153-66.
30. Koma BS, Bergh AM, Costa-Black KM. Barriers to and facilitators for implementing an office ergonomics programme in a South African research organisation. Appl Ergon. 2019;75:83-90.
31. Okoye EA, Ugbebor J, Adaramola S. Assessing the effectiveness of ergonomics practices in selected workplaces in Port Harcourt,

Nigeria. All Days. 2018 Aug 6; Available from: https://onepetro.org/SPENAIC/proceedings-abstract/18NAIC/All-18NAIC/216246
32. Mahmoud NA, Abu Raddaha AH, Zaghamir DE. Impact of Digital Device Use on Neck and Low Back Pain Intensity among Nursing Students at a Saudi Government University: A Cross-Sectional Study. Healthcare (Basel). 2022;10(12):2424.
33. Elvan A, Cevik S, Vatansever K, Erak I. The association between mobile phone usage duration, neck muscle endurance, and neck pain among university students. Sci Rep. 2024;14(1):20116.
34. Machado-Matos M, Arezes PM. Impact of a workplace exercise program on neck and shoulder segments in office workers. DYNA. 2016;83(196):63-68.
35. Karatrantou K, Gerodimos V. A Comprehensive Workplace Exercise Intervention to Reduce Musculoskeletal Pain and Improve Functional Capacity in Office Workers: A Randomized Controlled Study. Healthcare (Basel). 2024;12(9):915.
36. Barr-Anderson DJ, AuYoung M, Whitt-Glover MC, Glenn BA, Yancey AK. Integration of short bouts of physical activity into organizational routine a systematic review of the literature. Am J Prev Med. 2011;40(1):76-93.
37. Stults-Kolehmainen MA, Sinha R. The effects of stress on physical activity and exercise. Sports Med. 2014;44(1):81-121.
38. Puttipaibool S, Akarasereenont P, Chomchai S, Udomphorn Y, Asavamongkolkul A. Effects of Different Durations of 9-Square Dance Exercise Versus Treadmill Exercise on the Physical Fitness and Quality of Life of Healthy Volunteers: A Pilot Randomized Controlled Trial. Siriraj Med J. 2022;74(12):883-90.
39. Radwan A, Barnes L, DeResh R, Englund C, Gribanoff S. Effects of active microbreaks on the physical and mental well-being of office workers: A systematic review. Cogent Engineering. 2022;9(1).

Enhancing Orbital MRI Quality: Optimization of Saturation Pads for 1.5T

Sujitra Tinnut, M.D.[1,*], Suwimon Nabumrung, BS[1], Kornthip Jeephet, MPH[2], Kingkarn Aphiwatthanasumet, Ph.D.[3]

[1]Department of Radiology, Faculty of Medicine, Naresuan University, Thailand, [2]Clinical Epidemiology and Clinical Statistics Unit, Faculty of Medicine, Naresuan University, Thailand, [3]Department of Radiological Technology, Faculty of Allied Health Sciences, Naresuan University, Thailand.



**Corresponding author: Sujitra Tinnut*
E-mail: sujitrati@nu.ac.th
Received 29 October 2024 Revised 8 January 2025 Accepted 9 January 2025
ORCID ID:http://orcid.org/0000-0003-0035-4020
https://doi.org/10.33192/smj.v77i5.271939

ABSTRACT

Objective: This study aimed to compare the effectiveness of different eye pads in enhancing magnetic field homogeneity using the Spectral Presaturation with Inversion Recovery (SPIR) technique.

Materials and Methods: A prospective study was approved by the Ethics Committee and involved thirty patients undergoing orbital MRI with no current abnormalities. Patients were randomly assigned to one of three groups: uncooked jasmine rice, polystyrene ball bullet foam, or sugar cane syrup. Each patient underwent imaging twice - first without a pad and then with a pad on the eyelid. An experienced neuroradiologist, blinded to pad compositions, evaluated the images quantitatively and qualitatively. Statistical analyses included the Kruskal-Wallis rank test for signal-to-noise (SNR) and contrast-to-noise ratios (CNR), Dunn's test for post-hoc comparisons, the Wilcoxon signed-rank test for qualitative pre- and post-pad differences, and Fisher's exact test for group differences, with significance set at $P < 0.05$.

Results: The uncooked jasmine rice group showed higher SNR and CNR, particularly in the medial rectus muscle (MRM). Significant improvements in the visual scale were noted for the optic nerve sheath complex ($P = 0.002$), MRM ($P = 0.005$), motion artifact ($P = 0.034$), and susceptibility artifact ($P = 0.030$) in both the uncooked jasmine rice and sugar cane syrup groups. Notably, none of the participants in the rice group exhibited a degraded visual scale for MRM or increased susceptibility artifact after pad placement.

Conclusion: This study highlights the effectiveness of uncooked jasmine rice and sugar cane syrup as materials for enhancing orbital MRI quality, especially in earlier scanner models.

Keywords: Fat suppression; Orbit; MRI; Saturation pad; SPIR (Siriraj Med J 2025; 77: 456-465)

INTRODUCTION

Magnetic resonance imaging (MRI) stands out as the preferred modality, offering heightened sensitivity compared to alternative imaging techniques for evaluating the orbit, especially the retrobulbar visual pathway.[1] The coronal plane is favored as it effectively illustrates anatomical relationships.[2,3] The fat-suppressed sequence becomes an essential and excellent technique for detecting orbital pathology, further distinguishing fat-containing masses from others and leading to a more accurate diagnosis.[2,4,5]

Currently, there are various techniques for suppressing retrobulbar fat, unique with its own advantages and disadvantages. The Dixon technique is an MRI sequence based on chemical shift, which is designed for uniform fat suppression. It has been growing in popularity due to its advantages over other methods. However, older-generation MRI Scanners still have some limitations. The most effective fat suppression technique for these earlier scanners is Spectral Presaturation with Inversion Recovery (SPIR). SPIR is a hybrid technique that combines both fat saturation and inversion recovery methods. It utilizes a fat-selective radiofrequency pulse and spoiler gradient like chemical shift selective saturation (CHESS), while also nullifying residual longitudinal fat magnetization through an inversion delay mechanism similar to short tau inversion recovery (STIR). However, SPIR still faces challenges due to magnetic field inhomogeneity, particularly at tissue interfaces. Incomplete fat suppression and darkening in the images due to signal degradation are still common in orbital MRI, especially adjacent paranasal sinuses (air-tissue) and the skull base (bone-tissue). These artifacts adversely affect the image quality and interpretation, posing a challenge, especially in earlier scanners in our department.

Previous studies explored various materials for saturation bags, such as sponge pillows, uncooked rice, acrylic and glass beads, flour, bath salts, perfluorocarbon liquids, and polystyrene and polypropylene beads, to reduce inhomogeneity in MRI scans.[6–15] Findings from these studies indicated that material such as glass beads, bath salts, polystyrene, rice, and flour were effective in enhancing image quality by minimizing susceptibility artifacts. Notably, while these materials have shown promise, they did not uniformly address the specific challenges associated with orbital imaging, particularly concerning artifacts from adjacent tissues like the paranasal sinuses and skull base. Existing solutions often face limitations in terms of cost, availability, and effectiveness in the orbital region, creating a significant gap in the current literature. In this context, we propose sugar cane syrup as a novel and cost-effective alternative to perfluorocarbon liquid pads for enhancing orbital MRI quality. Our hypothesis is that sugar cane syrup, with its unique rheological and magnetic properties, can provide improved magnetic field homogeneity, thereby enhancing image quality in

the orbital region. This study aims not only to evaluate the effectiveness of sugar cane syrup but also to provide a critical comparison of its performance against established materials, leading to a more comprehensive understanding of potential solutions for optimizing orbital MRI.

The aim of our study was to assess the most effective eye pad for enhancing magnetic field homogeneity within the context of the SPIR technique, specifically focusing on the evaluation of orbital anatomy in the coronal plane. We examined three materials—uncooked jasmine rice, polystyrene ball bullet foam, and sugar cane syrup—selected for their convenience, affordability, and the inconclusive results from previous research. Each material exhibits distinct diamagnetic properties, which may lead to varying degrees of improvement in image quality.

MATERIALS AND METHODS

Patient Population

This descriptive prospective study was approved by the IRB No.P3-0015/2564. Thirty patients who underwent orbital MRI at our department between June 7, 2021 and June 10, 2023 and had no current orbital abnormality were recruited. All patients gave informed consent prior to participation in this study. Using a simple random sampling technique (lottery method), the patients were categorized into three groups: uncooked jasmine rice group, polystyrene ball bullet foam group, and sugar cane syrup group.

Image acquisition

All patients were scanned on a 1.5 Tesla MRI scanner (Philips Ingenia, Philips Medical Systems, Best, the Netherlands), release 4.1.3.3 software version (installed August 2014) using a conventional head array coil. A coronal spin-echo T2-weighted (T2W) sequence was acquired with the following parameters: TR = 3000 msec, TE = 70 msec, FOV 130x149 mm, 3 mm slice thickness, number of signal acquisitions = 2, 216x210 matrix size, and shim mode = auto shimming. The shim values were automatically selected based on the MRI scanner's shimming algorithm within the imaging FOV. For each patient, a T2W coronal image with fat suppression technique was acquired twice: 1) with nothing on the eyelids, and 2) with a pad placed on the closed eyelid (Fig 1). The SPIR technique was used to suppress fat signals in orbital MRI.

Pad design

This study utilized uncooked jasmine rice, polystyrene ball bullet foam, and sugar cane syrup, which were utilized to enhance the magnetic field. The bags, constructed from latex material, were safe (i.e., nontoxic and nonirritating), and posed no adverse effects within the magnetic field. Fig 2 illustrates a small, round latex rubber balloon (4 inches in diameter) filled with these materials. The jasmine rice bag, which weighed 65.05 g, contained long-grain, opaque white grains. The polystyrene ball bullet foam was spherical and measured 2 mm in diameter, with the foam bag weighing 3.72 g. The sugar cane syrup bag weighed 58.08 g, prepared at a concentration of 77 Brix solution. At 20°C, 1 Brix is equivalent to 1 g of sugar in 100 g of water and sugar solution. This solution contains 1.08 kg of sugar per one liter of water and the cane syrup will had a density value of 1.39 g/L. All pads were standardized to have a uniform size and shape, regardless of fill material. A visual inspection was conducted before usage to identify potential issues such as leaks, damage, or other defects.

Fig 1. The figure illustrates the placement of the saturation pad on the patient's eye in relation to the conventional head array coil.

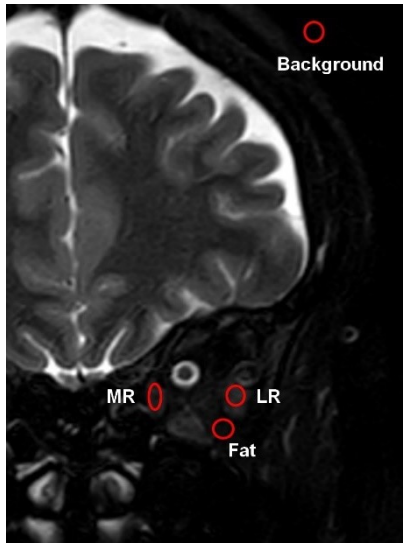


Fig 2. Quantitative assessment of normal intraorbital anatomy was conducted by drawing a red circle respecting anatomical borders, covering approximately 0.1 cm^2. This method included labeling the medial rectus (MR), lateral rectus (LR), and intraconal fat, and background area.

Image evaluation

All included patients, both with and without placed saturation pads, were reviewed by a neuroradiologist with 5 years of experience who was blinded to the material composition of the pads. Both qualitative and quantitative assessments of normal intraorbital anatomy were performed before and after pad placement.

The signal intensity (SI) of anatomy was measured using a circular region of interest (ROI) for quantitative assessment. The size of the ROI area was standardized in the coronal plane, and precisely drawn to be 0.1 cm^2 with respect to anatomical borders, at the medial rectus muscle (MRM), lateral rectus muscle (LR), inferolateral extraconal fat, and background (Fig 3). The signal-to-noise ratio (SNR) was measured by calculating the mean SI within a region of interest (MRM, LR, and fat) and dividing it by the standard deviation of the noise in a background area (the air) where no signal is present. Contrast-to-noise ratio (CNR) was measured by calculating the mean SI of two different ROIs (MRM/fat and LR/fat) within the image and dividing them by the standard deviation in a background area (the air).

For qualitative assessment, a five-point numeric scale was used to evaluate the visibility of structures: 1, non-visualization; 3, indeterminate; and 5, definite visualization.[16] Both normal orbital anatomy and pericavernous structures were evaluated, including optic nerve sheath complex (ON), superior ophthalmic vein (SOV), MRM, LR, inferior rectus muscle (IR), dural reflection, Meckel's cave, pituitary gland, and temporal lobe. Magnetic susceptibility due to the paranasal sinuses and mastoid air cells, motion artifact due to head and globes movement were also rated on a five-point scale: 1, indicates blurring of surrounding structures due to artifact; 3, artifact is present, but structures are distinguishable; and 5, no artifact.[16] The visual assessment scale is illustrated in Fig 4.

Statistical analysis

All statistical analyses were performed using Stata version 17.0. Demographic numerical data were displayed as the mean and SD, whereas categorical data were represented by frequencies and percentages. To compare the three different pad groups, we used analysis of variance

Fig 3. The pads were created by filling small latex bags with various materials: polystyrene ball bullet foam (left), uncooked jasmine rice (middle), and sugar cane syrup (right). The images show the materials before filling the pads (top row) and the completed pads (bottom row).

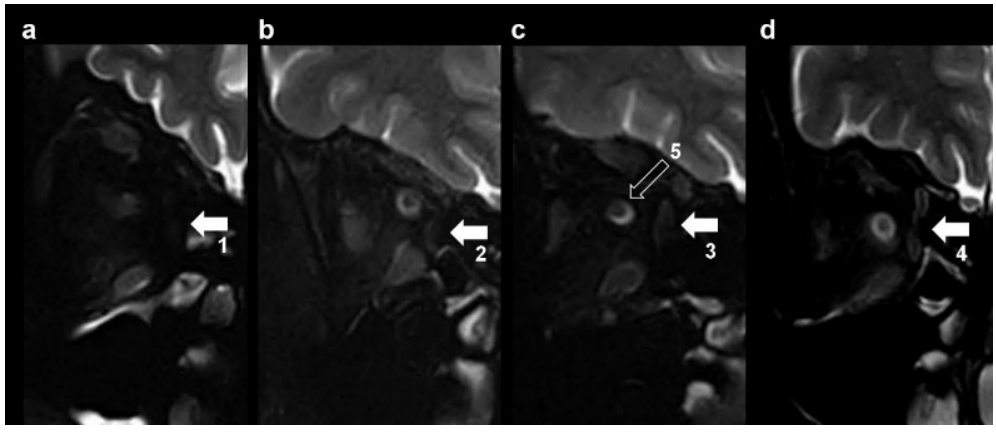


Fig 4. Coronal T2W images of the orbit illustrate the visual assessment scale ranging from 1 to 5 (a–d). In image "a," the medial rectus muscle (MRM, arrow) is rated as 1, indicating it is non-visualized, totally obscured by artifact. In image "b," it is rated as 2, with the margins of the MRM not clearly demarcated. In image "c," the MRM shows a rating of 3, displaying visible artifacts but distinguishable structures; however, signal intensity cannot be assessed. In image "d," the rating is 4, indicating that signal intensity can be assessed despite minimal artifacts. Additionally, the optic nerve (ON, open arrow) in image "c" is rated as 5, indicating exceptional clarity and absence of artifacts. This assessment is based on the criteria outlined in the study.

and the Fisher's exact test. For quantitative assessment, the Kruskal–Wallis rank test and a post-hoc test were used, and the results were presented as medians and interquartile range (IQR). The significance level was set at less than 0.05. For the qualitative analysis, we calculated the differences in scale between before and after pad placement for each patient, orbit, and anatomical structure. The ordinal data were presented as frequencies and proportions. Fisher's exact test was used to test for significant differences among the groups of three material pads. A p-value of 0.05 or less is considered statistically significant.

RESULTS

The mean ages of patients in each group were as follows: 52.50±16.08 for the uncooked jasmine rice group, 45.20±14.76 for the polystyrene ball bullet foam group, and 58.40±17.49 for the sugar cane syrup group. In the uncooked jasmine rice group, there was an equal number of male and female patients, with 5 individuals in each category. The polystyrene ball bullet foam group had 7 males and 3 females. The sugar cane syrup group had 4 males and 6 females. Table 1 shows that there are no significant differences in patient characteristics among the groups.

Orbital anatomy

The uncooked jasmine rice group exhibited notably higher SNR and CNR, particularly in the MRM, when compared to the other two groups (Table 2). However, there was no significant difference observed in the MRM and LR for quantitative assessment, as determined by the Kruskal–Wallis rank test and a post-hoc test.

Visual scale improvements were evident in both the uncooked jasmine rice and sugar cane syrup groups (Fig 5). In particular, the uncooked jasmine rice group demonstrated a significant increase in visibility of the ON at 95% (P = 0.002), motion artifact at 55% (P = 0.034), and susceptibility artifact at 95% (P = 0.030). Meanwhile, the sugar cane syrup group displayed a remarkably enhanced visibility of the MRM at 95% (P = 0.005). Although the remaining orbital structures (SOV, LR, and IR) showed trends toward improved visibility in the sugar cane syrup group, no statistically significant difference was observed. The results are presented in Table 3.

TABLE 1. Demographic data.

Variable	Uncooked Jasmine Rice	Polystyrene Ball Bullet	Sugar Cane Syrup	P-value
Age (year), mean±SD	52.50±16.08	45.20±14.76	58.40±17.49	0.206
Sex, N (%)				0.534
Female	5 (50.0)	7 (70.0)	4 (40.0)	
Male	5 (50.0)	3 (30.0)	6 (60.0)	

TABLE 2. Quantitative assessment of orbital structures.

Quantitative assessment Median (IQR)	Uncooked Jasmine Rice	Polystyrene Ball Bullet	Sugar Cane Syrup	P-value
SNR Medial rectus muscle	4.85 (0.45-14.45)	2.75 (0.20-6.95)	3.40 (2.95-8.55)	0.402
SNR Lateral rectus muscle	2.75 (2.25-10.40)	2.70 (2.30-6.10)	1.60 (0.39-4.60)	0.384
SNR Inferior extraconal fat	0.55 (0.25-5.15)	1.55 (0.55-2.40)	0.05 (0.00-3.45)	0.428
CNR Medial rectus muscle	0.30 (0.05-0.65)	0.20 (0.00-0.70)	0.15 (0.03-0.35)	0.409
CNR Lateral rectus muscle	0.15 (0.00-0.8)	0.00 (0.00-0.55)	0.15 (0.08-0.15)	0.255

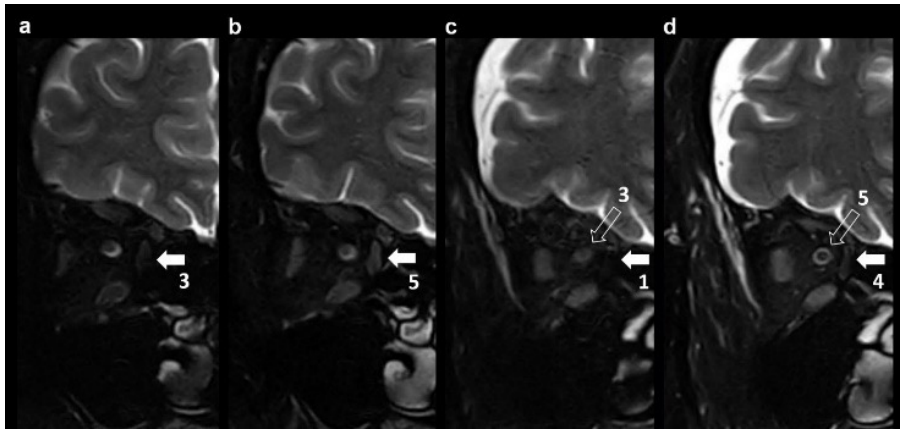


Fig 5. Coronal T2W images demonstrate the improvement in visibility of the medial rectus muscle (MRM, arrow) and optic nerve (ON, open arrow) before and after pad placement, as assessed by a quantitative scale. In the sugar cane syrup group (a, b), MRM visibility increases from 3 to 5. In the uncooked jasmine rice group (c, d), MRM visibility increases from 1 to 4, while ON visibility improves from 3 to 5. These results highlight the effectiveness of the two pad materials in enhancing image quality.

TABLE 3. Visual assessment of orbital structures.

Orbital structures N (%)	Uncooked Jasmine Rice	Polystyrene Ball Bullet	Sugar Cane Syrup	P-value
Optic nerve-optic sheath complex				
Improvement	19 (95.0)	9 (45.0)	14 (70.0)	0.002*
No change	0 (0)	3 (15.0)	2 (10.0)	0.353
Degradation	1 (5.0)	8 (40.0)	4 (20.0)	0.024*
Superior ophthalmic vein				
Improvement	11 (55.0)	8 (40.0)	12 (60.0)	0.521
No change	4 (20.0)	4 (20.0)	2 (10.0)	0.749
Degradation	5 (25.0)	8 (40.0)	6 (30.0)	0.692
Extraocular muscles				
Medial rectus muscle				
Improvement	18 (90.0)	10 (50.0)	19 (95.0)	0.005*
No change	2 (10.0)	4 (20.0)	0 (0)	0.150
Degradation	0 (0)	6 (30.0)	1 (5.0)	0.013*
Lateral rectus muscle				
Improvement	14 (70.0)	9 (45.0)	15 (75.0)	0.126
No change	4 (20.0)	6 (30.0)	2 (10.0)	0.346
Degradation	2 (10.0)	5 (25.0)	3 (15.0)	0.572
Inferior rectus muscle				
Improvement	16 (80.0)	14 (70.0)	18 (90.0)	0.346
No change	3 (15.0)	1 (5.0)	0 (0)	0.310
Degradation	1 (5.0)	5 (25.0)	2 (10.0)	0.246
Motion artifact				
Improvement	11 (55.0)	3 (15.0)	6 (30.0)	0.034*
No change	7 (35.0)	5 (25.0)	8 (40.0)	0.698
Degradation	2 (10.0)	12 (60.0)	6 (30.0)	0.004*
Susceptibility artifact				
Improvement	19 (95.0)	12 (60.0)	16 (80.0)	0.030*
No change	1 (5.0)	4 (20.0)	3 (15.0)	0.505
Degradation	0 (0)	4 (20.0)	1 (5.0)	0.115

**Statistically significant*

Furthermore, our study identified a degraded visual scale for all orbital structures in the polystyrene ball bullet foam group. Specifically, the visual scale of the ON, MRM, and motion artifact was significantly degraded. In the uncooked jasmine rice group, no participant showed a degraded visual scale of the MRM and susceptibility artifact after pad placement.

Pericavernous structures

There was no statistically significant difference observed for pericavernous structures among all three groups. Table 4 illustrates the percentage distribution of each structure across the groups.

DISCUSSION

The importance of fat suppression techniques in enhancing the visibility of orbital pathology is undeniable. SPIR is commonly utilized in Philips scanners as the default method due to its use of RF pulses and inversion recovery to suppress fat signals while maintaining signals from other tissues. However, the effectiveness of fat suppression remains dependent on the uniformity of both the main magnetic field (B0) and the radiofrequency magnetic field (B1) due to the combined CHESS technique. The persistent issue of orbital MRI is the inhomogeneity caused by tissue interfaces, which can limit diagnostic accuracy. Using material pads is a valuable method to

TABLE 4. Visual assessment of pericavernous structures.

Pericavernous structures N (%)	Uncooked Jasmine Rice	Polystyrene Ball Bullet	Sugar Cane Syrup	P-value
Dural reflection				
Improvement	20 (100.0)	18 (90.0)	18 (90.0)	0.532
No change	0 (0)	1 (5.0)	0 (0)	1.000
Degradation	0 (0)	1 (5.0)	2 (10.0)	0.766
Meckel's cave				
Improvement	13 (65.0)	12 (60.0)	15 (75.0)	0.698
No change	6 (30.0)	6 (30.0)	5 (25.0)	1.000
Degradation	1 (5.0)	2 (10.0)	0 (0)	0.766
Pituitary gland				
Improvement	19 (95.0)	20 (100.0)	20 (100)	1.000
No change	0 (0)	0 (0)	0 (0)	1.000
Degradation	1 (5.0)	0 (0)	0 (0)	1.000
Motion artifact				
Improvement	18 (90.0)	16 (80.0)	16 (80.0)	0.749
No change	2 (10.0)	0 (0)	1 (5.0)	0.766
Degradation	0 (0)	4 (20.0)	3 (15.0)	0.144
Susceptibility artifact				
Improvement	8 (40.0)	5 (25.0)	11 (55.0)	0.174
No change	11 (55.0)	15 (75.0)	9 (45.0)	0.188
Degradation	1 (5.0)	0 (0)	0 (0)	1.000
Temporal lobe				
Improvement	18 (90.0)	12 (60.0)	16 (80.0)	0.099
No change	2 (10.0)	8 (40.0)	2 (10.0)	0.370
Degradation	0 (0)	0 (0)	2 (10.0)	0.322

address this issue and enhance image quality, especially when dealing with limited scanners.[9,11,14,15,17]

In our study, we enrolled 30 patients who underwent MRI and had no orbital abnormality. We found that the uncooked jasmine rice was more effective than other materials for improving image quality, which is supported by prior research.[6,10,12] This improvement was particularly notable in the ON, with a significant reduction in both motion and susceptibility artifacts. However, these findings contrast with the study by Teshigawara et al. that explored five pad materials for fat suppression in a breast-simulated phantom using a 3D T1W sequence.[7] Their result did not identify rice as the optimal pad material. The discrepancies between our results and theirs may arise from the differences in imaging sequences and the use of phantom studies. Additionally, the aspect of material discomfort in their study may have influenced the different outcomes.

The improvement of MRM visualization, which was often obscured by susceptibility artifact from the nearby paranasal sinuses, revealed a significant difference among the three groups. The results showed a 95% improvement in the sugar cane syrup group and a 90% improvement in the uncooked jasmine rice group. However, the trend was reversed for susceptibility artifact improvement, which could be explained by the susceptibility values of materials. In addition, all three materials have diamagnetic properties. Their magnetic susceptibility values are small and slightly negative, within the range of 10^{-6} to 10^{-7}. Uncooked rice has an estimated magnetic susceptibility of -8.2×10^{-7} emu (with 1 emu equal to 1 cm^3), while polystyrene has a susceptibility of -7.5×10^{-6} emu.[6,18] The susceptibility value of rice is similar to that of human tissue (-11×10^{-6} to -7×10^{-6} emu).[19] It is possible that diamagnetic susceptibility interactions can result in minimal variations in the precession frequency of protons, leading to intravoxel inhomogeneity and chemical shift variation. The effect of susceptibility differences becomes apparent in the behavior of diamagnetic substances when placed in a magnetic field. However, further studies are necessary to better clarify the susceptibility-induced artifacts of diamagnetic substances.

Furthermore, our study also found a significantly degraded visual scale of the ON and MRM in the group of polystyrene ball bullet foam because of increased motion artifacts. This suggests that polystyrene ball bullet foam may not be a suitable material, as it resulted in degraded visibility of all intraorbital structures. This could result from the lightweight nature of the polystyrene ball bullet pad, and it potentially has less surface contact with the eyelid compared to the others, further causing field inhomogeneity and motion, affecting the image quality. In contrast, the study by Ikeguchi et al. evaluated fat suppression in six healthy volunteers who performed MRI of the head and neck.[20] Their findings indicated that the improvement of fat suppression using the STIR technique was similar among all three pads (commercial pad, uncooked rice, and polystyrene ball bullet). However, inconsistency may be attributed to variations in anatomical location, differences in the criteria for the visual assessment scale (using 4-point scales), and the smaller sample sizes in their studies. Despite these promising results, several questions remain unanswered. Future research should focus on refining these techniques to enhance diagnostic accuracy and image quality, particularly in the context of pathological cases where precise imaging is crucial. Modern MRI scanners, equipped with advanced hardware and software, offer opportunities to address challenges such as subtle lesion detection, artifact minimization, and tissue differentiation.

Limitations

This study had several limitations. First, we focused on a single sequence (T2W) and a single imaging plane (coronal) using a 1.5 T magnet. The degree of artifacts may vary based on the technique used, but we respectfully acknowledge that our protocol and setup represent common practices observed in many hospitals using Philips scanners. Second, we used a qualitative assessment using a 5-point scale, ranging from 1 (blurry due to artifacts) to 5 (completely clear with no artifact), which could introduce some subjectivity. However, we believe this visual scale allowed us to capture degrees of uncertainty better than previous studies. Third, the window levels and widths of the images were not set consistently[21], which could potentially impact interpretation. Fourth, the potential influence of inflammatory mucosal changes in the paranasal sinuses, particularly in the ethmoid and maxillary sinuses, on the magnetic field homogeneity was not accounted for in our study. Fifth, as only one radiologist reviewed the images, the generalizability of our findings might be limited. Involving multiple radiologists could provide a diverse perspective and enhance the reliability of the results. Sixth, the radiologist was unblinded in the group of sugar cane syrup because the images of the anterior globe and eyelids were not obscured, which introduced bias into the assessment. Seventh, while saturation pads may not be considered cutting-edge technology and are less commonly utilized in modern scanners with advanced fat suppression techniques such as the Dixon technique, their value remains significant for enhancing image quality in older MRI scanners limited to basic fat

suppression methods like STIR or SPIR. Finally, it is important to note that we only evaluated patients with presumed normal orbital structures. We hope this result serves as a useful baseline for future research on patients with orbital pathologies. To address the subjective nature of the visual assessment, we suggest developing validation methods in future studies to improve reliability and usefulness.

CONCLUSION

This study highlights the utility of uncooked jasmine rice and sugar cane syrup as effective pads for improving image quality in orbital MRI. These findings provide a practical and affordable solution for addressing inhomogeneity, particularly in scanners with technical limitations.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

ACKNOWLEDGEMENTS

We gratefully acknowledge the hard work, efficiency, and devotion of our imaging technicians, which made this work possible as well as Mrs. Judely Marish Cruz Cañete and Miss Daisy Gonzales, for their assistance in editing and revising this manuscript.

DECLARATION

Grant and Funding Information

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

Registration Number of Clinical Trial

None.

Author Contributions

Conceptualization: S.T., K.A.; Methodology: S.T., K.A., K.J.; Data collection: S.T., K.J.; Formal analysis: K.J.; Writing – original draft preparation: S.T.; Writing – review and editing: S.T., K.A., K.J.

Use of Artificial Intelligence

We use ChatGPT exclusively to check English language and sentence structure in the manuscript, without contributing to any other parts of the content.

REFERENCES

1. Kennedy TA, Corey AS, Policeni B, Agarwal V, Burns J, Harvey HB, et al. ACR Appropriateness Criteria® Orbits Vision and Visual Loss. J Am Coll Radiol [Internet]. 2018;15(5, Supplement):S116–31. Available from: https://www.sciencedirect.com/science/article/pii/S154614401830351X
2. Grech R, Cornish KS, Galvin PL, Grech S, Looby S, O'Hare A, et al. Imaging of adult ocular and orbital pathology--a pictorial review. J Radiol Case Rep. 2014;8(2):1–29.
3. Lee AG, Johnson MC, Policeni BA, Smoker WRK. Imaging for neuro-ophthalmic and orbital disease - a review. Clin Experiment Ophthalmol. 2009;37(1):30–53.
4. Simon J, Szumowski J, Totterman S, Kido D, Ekholm S, Wicks A, et al. Fat-suppression MR imaging of the orbit. AJNR Am J Neuroradiol. 1988;9(5):961–8.
5. Tien RD. Fat-suppression MR imaging in neuroradiology: techniques and clinical application. AJR Am J Roentgenol. 1992;158(2):369–79.
6. Moriya S, Miki Y, Miyati T, Kanagaki M, Yokobayashi T. Flour pads: Devices to improve CHESS fat suppression. Magn Reson Med Sci. 2014;13(1):33–8.
7. Teshigawara M, Ogura A, Uchiyama N, Koganezawa T. The Optimal Pad Material for Fat Suppression of Breast MRI. Nihon Hoshasen Gijutsu Gakkai Zasshi. 2017;73(8):664-71.
8. Shiina R, Ogura A, Takeuchi T, Nakano H. Improvement of Fat Suppressing Effect for Finger and Neck MRI by Using Small Glass Beads. Nihon Hoshasen Gijutsu Gakkai Zasshi 2019;75(5):446-53.
9. Moriya S, Miki Y, Kamishima T, Kanagaki M, Yokobayashi T, Ishikawa M. Fat-suppressed MR images of both hands obtained using CHESS can be improved by rice pads. Eur J Radiol [Internet]. 2012;81(9):2318-22. Available from: http://dx.doi.org/10.1016/j.ejrad.2011.06.021
10. Moriya S, Miki Y, Yokobayashi T, Yamamoto A, Kanagaki M, Komori Y, et al. Rice and perfluorocarbon liquid pads: Comparison of fat suppression effects. Acta Radiol. 2010;51(5):534–8.
11. Moriya S, Miki Y, Yokobayashi T, Yamamoto A, Kanagaki M, Komori Y, et al. Improved CHESS imaging with the use of rice pads: Investigation in the neck, shoulder, and elbow. J Magn Reson Imaging. 2010;31(6):1504–7.
12. Moriya S, Miki Y, Yokobayashi T, Kanagaki M, Komori Y, Ishikawa M. Rice pads: Novel devices for homogeneous fat suppression in the knee. Acta Radiol. 2010;51(2):175–8.
13. Kang Y, Lee JW, Koh YH, Hur S, Kim SJ, Chai JW, et al. New MRI Grading System for the Cervical Canal Stenosis. Am J Roentgenol [Internet]. 2011 Jul 23 [cited 2020 Apr 29];197(1):W134–40. Available from: http://www.ajronline.org/doi/10.2214/AJR.10.5560
14. Cheol KB, Deok PH, Seok PK, Min PS, Gu SJ, Ok KJ, et al. A Study on the Usefulness of Polystyrene Pad for Fat Suppression Improvement. J Korean Soc MR Technol Vol. 27(2):31–6.
15. Eilenberg SS, Tartar M, Mattrey RF. Reducing magnetic susceptibility differences using liquid fluorocarbon pads (sat pad): Results with spectral presaturation of fat. Artif Cells Blood Substit Immobil Biotechnol. 1994;22(4):1477–83.
16. Mukherji SK, Tart RP, Fitzsimmons J, Belden C, McGorray S, Guy J, et al. Fat-suppressed MR of the orbit and cavernous sinus: comparison of fast spin-echo and conventional spin-echo. Am J Neuroradiol [Internet]. 1994;15(9):1707 LP – 1714. Available from: http://www.ajnr.org/content/15/9/1707.abstract

17. Moriya S, Miki Y, Yokobayashi T, Kanagaki M, Komori Y, Fujimoto K, et al. Rice pads reduce geometric distortion of echo-planar diffusion-weighted images of the cervical spinal cord. Magn Reson Med Sci. 2011;10(1):65–9.
18. Jin X, Zhao Y, Richardson A, Moore L, Williams PS, Zborowski M, et al. Differences in magnetically induced motion of diamagnetic, paramagnetic, and superparamagnetic microparticles detected by cell tracking velocimetry. Analyst. 2008;133(12):1767–75.
19. Mehrmohammadi M, Oh J, Mallidi S, Emelianov SY. Pulsed magneto-motive ultrasound imaging using ultrasmall magnetic nanoprobes. Mol Imaging. 2011;10(2):102–10.
20. Ikeguchi H, Shonai T, Mikami A, Yazawa N, Takahashi T, Yamada K. [Evaluation of prototype for additional pad packing (polystyrene ball bullet) for homogenously fat suppressed magnetic resonance imaging]. Nihon Hoshasen Gijutsu Gakkai Zasshi. 2013;69(1):71–9.
21. Oilmungmool N, Chattrapiban T, Tinnut S, Galassi W. Age-Related Changes in Signal Intensity Ratio of Normal Clivus Bone Marrow on Magnetic Resonance Imaging. Siriraj Med J. 2022; 74:381–7.