Sponge-incorporated VS Multilayer Padding Long Leg Cast to Prevent Pediatric Heel Pressure Injury: A Randomized Controlled Trial

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ABSTRACT

Objective: To measure and compare the incidence of cast-related pressure injuries at the heel between sponge-incorporated long leg cast and multilayer padding cast following orthopedic lower extremity surgery.

Materials and Methods: Patients aged 1 to 18 years who were scheduled for elective lower extremity soft tissue surgery were recruited. They were equally randomized into two groups: sponge-incorporated cast (Group 1) and multilayer padding cast (Group 2). A multilayer padding cast, consisting of five layers of Webril®, was applied to the heel and bony prominence areas. At the 2nd and 4th weeks postoperatively, cast-related heel pressure injuries were evaluated using the 2016 National Pressure Ulcer Advisory Panel (NPUAP) staging system. Changes in alignment and other complications were also recorded.

Results: 100 patients were recruited. At two weeks postoperatively, the incidence of cast-related heel pressure injuries in Group 1 was 4/46 cases (8.7%), with all cases being stage 1. In Group 2, there were 6/54 cases (11.1%), with 3 cases in stage 1 and 3 cases in deep tissue pressure injury (p=0.479). At four weeks postoperatively, Group 1 had 6/46 cases (13%), with 4/46 cases (8.7%) being stage 1 and 2/46 cases (4.3%) being deep tissue pressure injuries. Group 2 had 6/54 cases (11.1%) (p>0.99), with all cases being stage 1. There was no statistical difference in loss of alignment. No serious complications, such as compartment syndrome or neurovascular injury, were found.

Conclusion: The incidence of cast-related heel pressure injury was comparable between sponge padding cast and a multilayer cotton padding cast.

Trial registration: This study was registered in ClinicalTrails.gov (TCTR20220207002).

Keywords: Long leg cast; cast complications; sponge-incorporated cast, pressure injury (Siriraj Med J 2024; 76: 366-372)

INTRODUCTION

Cast immobilization is a common and effective treatment for the postoperative management of fractures and lower extremity soft tissue surgeries in pediatric patients. However, there are many cast-related complications such as thermal injuries, skin breakdown, pressure injuries, infections, blisters, dermatitis, neurological injuries, and compartment syndrome. One of the most common complications is pressure injury, which has been reported in 6.3% to 15% of children with cerebral palsy casts. Nearly 50% of pressure injuries occur in the heel area within the first four weeks after the application of a long leg cast or A-frame cast.[1] The initial stage of a pressure injury develops in the superficial tissues, presenting with purple or maroon discoloration. Later stages may progress to involve subcutaneous tissue, muscle, and bone, potentially causing osteomyelitis.[2] Significant pain and disability are common. The ulcer may become infected and require

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surgical debridement.[3] It is also associated with additional costs and increased loss of school or work days due to cast removal or other secondary procedures.[4] Patients who are obese or unable to communicate effectively, such as those who are obtunded, sedated, or very young, are at increased risk of complications during cast treatment.[5] Comorbidities that impair mobility may also increase the risk for cast-related complications.[6] Patients with cerebral palsy and spina bifida who have never been casted exhibit an increased risk for cast-related pressure injuries.[7]

Few previous studies reported a decrease in cast-related complications by using foam padding and wool felt padding.[1,8-11] One study of lower extremity casts in patients who were receiving chemotherapy, or those who had presented with heel soreness, reported that foam padding decreased the rate of pressure injuries.[9] Another retrospective study of foam padding in postoperative lower extremity casting reported a decrease heel pressure injuries, but the study had several limitations.[2]

To date, no Level I study has compared the incidence of pressure injuries in sponge-padded casts with multilayer-padded casts. Therefore, we hypothesized that sponge-incorporated casts would decrease the rate of heel pressure injuries compared to multilayer padding casts in children following orthopedic lower extremity surgery.

MATERIALS AND METHODS

This prospective, randomized controlled trial was conducted at a tertiary university hospital. Approval was obtained from the hospital ethics committee (study no. Si 710/2020), and all patients provided written informed consent. The study was conducted from September 2020 to October 2022. Patients aged 1-18 years who underwent elective soft tissue surgery and postoperative immobilization with long leg casting were included. Patients with preexisting wounds in the heel area or impaired sensation, such as those with myelomeningocele, were excluded. Subjects were randomized using computer-generated sequencing to receive either a sponge-incorporated long leg cast or a multilayer padded long leg cast (Fig 1). After surgery, the circular cast was applied by one of three pediatric orthopedic staff members who used the same padding technique.

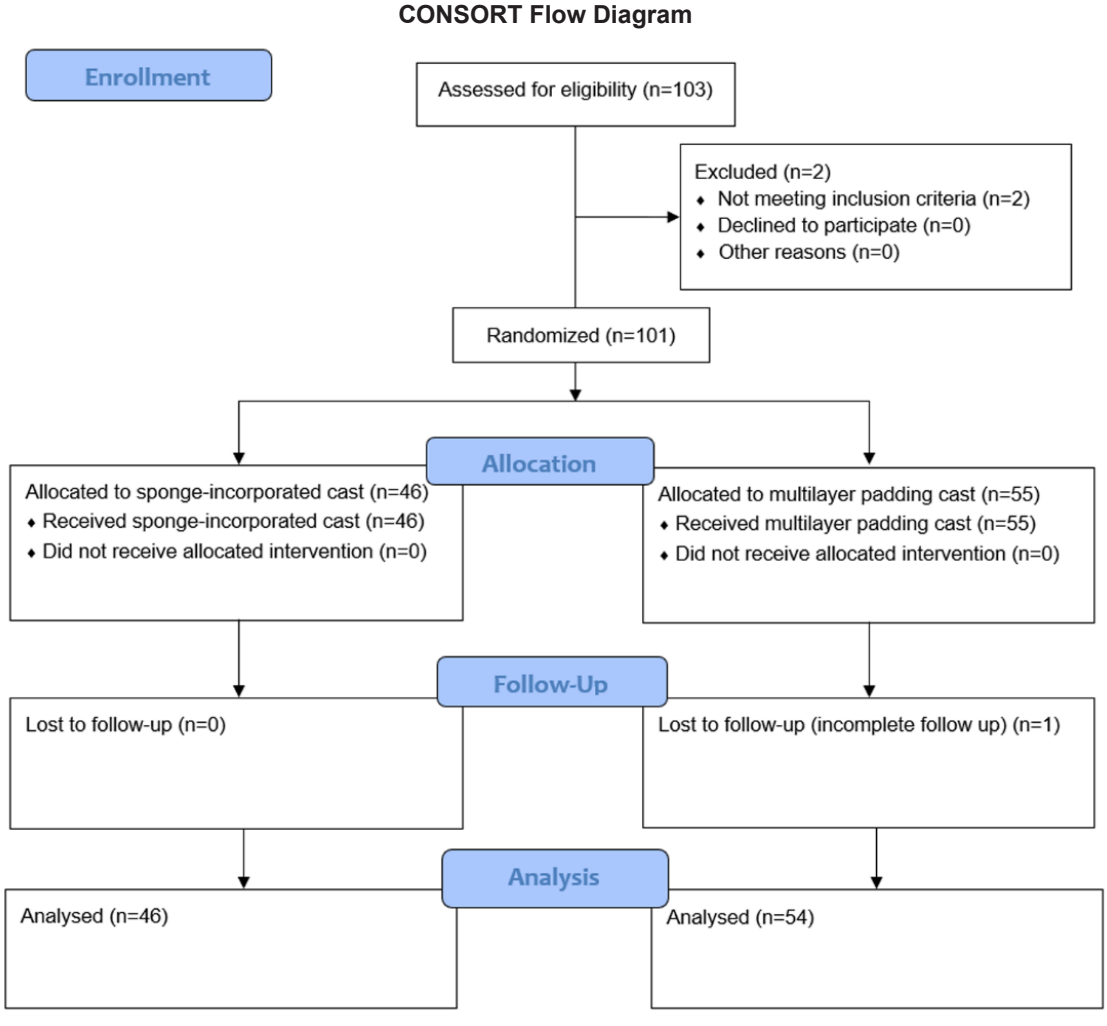

Fig 1. The Consolidated Standards of Reporting Trials (CONSORT) Flow Diagram.

The sponge-incorporated cast included two layers of Webril® applied from the toes to mid-thigh, followed by a one-centimeter-thick sponge applied at the heel area (Fig. 2). An additional single layer of Webril® was applied to cover the sponge, and two more layers of Webril® were added at the medial and lateral malleolus, fibular head, patella, and upper border of the cast. Next, a fiberglass (Scotch cast 3M®) cast was applied from the toes to the mid-thigh. The multilayer padding cast consisted of three layers of Webril® padding from toes to mid-thigh, with two additional layers at the bony prominences and the upper border of the cast. The padding technique in both casts was the same, except in the heel area where the sponge-incorporated cast used a sponge, whereas the multilayer padding cast used an additional two layers of Webril® instead. In both groups, the cast was applied during full knee extension and in a neutral plantigrade foot position. Postoperative protocols were the same for all patients. The sponge padding used in this study (Jolly®) was low-density sponge and commercially available. It is a porous, lightweight, flexible synthetic material made of polyurethane that conforms well to bony prominences. The heel was defined as the area at the posterior of the foot, extending from the Achilles tendon insertion to the apex of the calcaneal bone on the plantar surface.

Fig 2. (**A**) The sponge padding was applied at patient's heel. (**B**) Sponge-incorporated long leg cast.

The primary outcome was the incidence of heel pressure injury at two and four weeks postoperatively. Demographic information, including age, gender, body weight, height, side and operative procedure, were recorded. Cast condition, other areas of pressure injury, other complications and alignment of the knee and ankle were also recorded during the follow-up period. The cast was removed by a technician and sent to be evaluated for pressure injury in another room by an orthopedic resident who was blinded to the intervention. Pressure injury was evaluated using the 2016 NPUAP Pressure Injury Staging System 10, ranging from stage 1 to 4 and deep tissue pressure injury (DTPI). Stage 1 was intact skin with a localized area of nonblanchable erythema, which may appear differently in darkly pigmented skin and also presence of blanchable erythema or changes in sensation, temperature, or firmness may precede visual changes. Stage 2 was partial-thickness loss of skin with exposed dermis. The wound bed is viable, pink or red, moist, and may also present as an intact or ruptured serum-filled blister. Stage 3 was full-thickness skin loss, in which adipose (fat) is visible in the ulcer and granulation tissue and epibole (rolled wound edges), is often present. Slough and/or eschar may be visible. Stage 4 was full-thickness skin and tissue loss with exposed or directly palpable fascia, muscle, tendon, ligament, cartilage, or bone in the ulcer. Lastly, deep tissue pressure injury (DTPI) was Intact or nonintact skin with localized area of persistent nonblanchable deep red, maroon, purple discoloration, or epidermal separation revealing a dark wound bed or bloodfilled blister.

Total time for long leg cast immobilization in this study was 4 weeks. In cases that patients have heel pressure injury at 2 weeks postoperatively, the cast will be opened in a window fashion at the pressure injury area, bivalved, and the immobilization will continue until 4 weeks.

Statistical analysis

The statistical analysis was performed using SPSS version 18. The independent t test was utilized to compare body weight between groups. The chi-square test was utilized to compare operative procedure between groups. The Mann-Whitney test was utilized to compare age, height and body mass index between groups. The Fisher exact test was utilized to compare side and incidence of pressure injury between groups.

RESULTS

The result of 100 cases, 46 patients were allocated to the sponge-incorporated long leg cast group (Group 1) and 54 patients were allocated to the multilayer padding

long leg cast group (Group 2). Two patients were excluded because of impaired sensation due to myelomeningocele. There were no significant differences in demographic characteristics between two groups (Table 1). The operative procedures in Group 1 were tendo-achilles lengthening (TAL) 78.3%, hamstring release 6.5%, tendon transfer 4.3%, and combined procedures 10.9%. The operative procedures in Group 2 were tendo-achilles lengthening (TAL) 64.8%, hamstring release 7.4%, tendon transfer 9.3%, and combined surgical procedures 18.5%.

In Group 1, at 2 weeks postoperatively, the incidence of heel pressure injury was 4/46 (8.7%), all of which were stage 1 heel pressure injuries. At 4 weeks postoperatively, 6/46 cases (13%) had pressure injuries, with 4/46 (8.7%) being stage 1 and 2/46 cases (4.3%) being deep tissue pressure injuries. In Group 2, at 2 weeks postoperatively, the incidence of heel pressure injury was 6/54 cases (11.1%), with 3/54 (5.5%) being stage 1 and 3/54 cases (5.5%) being deep tissue pressure injuries. At 4 weeks postoperatively, 6/54 cases (11.1%) were stage 1 (Tables 2 and 3). There was no statistically significant difference in either group at 2 or 4 weeks postoperatively. Additionally, there was no statistically significant difference between cerebral palsy and non-cerebral palsy patients. (Table 4)

The pressure injury primarily occurred at the heel, followed by the ankle, thigh, foot, and leg. One patient was lost to follow-up. At two weeks postoperative, there were no reports of loss of alignment exceeding 10 degrees in both groups. Additionally, there were no serious complications such as compartment syndrome and neurovascular injury in either group.

TABLE 1. Patient demographic data and operative procedure

Variables	Sponge-incorporated cast (n = 46)	Multilayer padding cast (n=54)	P-value
Gender (Male)	29(63.0%)	30(55.6%)	0.542
Age (yr) †	8(6 – 12.25)	7(5.8 - 10)	0.183
Weight (kg) †	26.7(17.1 – 40.6)	21.8(15.9 – 41.1)	0.233
Height (cm) ‡	128.4±26.5	122.9±25.1	0.305
BMI (kg/m^2) †	17.4(14.3 – 21.7)	16.4(14.9 – 21.5)	0.809
Side (Right)	21(45.7%)	27(50.0%)	0.692
Communicable	45(97.8%)	48(88.9%)	0.120
Comorbidities			
Cerebral palsy	18(39.1%)	29(53.7%)	0.063
Healthy	16(34.8%)	17(31.5%)	0.832
Procedure			
Tendo-Achilles lengthening (TAL)	36(78.3%)	35(64.8%)	0.185
Hamstring release	3(6.5%)	4(7.4%)	>0.999
Combined surgery	5(10.9%)	10(18.5%)	0.401
Tendon transfer	2(4.3%)	5(9.3%)	0.447

†Median(Q1-Q3), ‡Mean±SD

TABLE 2. Outcome measurement at 2 weeks postoperatively

Variables	Sponge-incorporated cast [N (%)]	Multilayer padding cast [N (%)]	P-value
Heel pressure injury	4/46 (8.7%)	6 /54(11.1%)	0.479
Heel ulcer NPUAP staging			
Stage 1	4/46 (8.7%)	3/54 (5.5%)	NA
Stage 2	0 (0%)	0 (0%)	
Stage 3	0 (0%)	0 (0%)	
Stage 4	0 (0%)	0 (0%)	
DTPI[1]	0 (0%)	3/54 (5.5%)	
Anatomic location			NA
Heel	4 (80%)	3 (37.5%)	
Foot (Other)	0 (0%)	0 (0%)	
Thigh	0 (0%)	1 (12.5%)	
Ankle	1 (20%)	3 (37.5%)	
Knee	0 (0%)	1 (12.5%)	
Leg	0 (0%)	0 (0%)	

[1] DTPI, Deep tissue pressure injury

TABLE 3. Outcome measurement at 4 weeks postoperatively

Variables	Sponge-incorporated cast [N (%)]	Multilayer padding cast [N (%)]	P-value
Heel pressure injury	6/46 (13%)	6/54 (11.1%)	>0.999
Heel ulcer NPUAP staging			
Stage 1	4/46 (8.7%)	6/54 (11.1%)	NA
Stage 2	0 (0%)	0 (0%)	
Stage 3	0 (0%)	0 (0%)	
Stage 4	0 (0%)	0 (0%)	
DTPI[1]	2/46 (4.3%)	0 (0%)	
Anatomic location			NA
Heel	6 (85.7%)	6 (85.7%)	
Foot (Other)	0 (0%)	0 (0%)	
Thigh	0 (0%)	0 (0%)	
Ankle	1 (14.3%)	1 (14.3%)	
Knee	0 (0%)	0 (0%)	
Leg	0 (0%)	0 (0%)	

[1] DTPI, Deep tissue pressure injury

TABLE 4. Compare heel pressure injury in cerebral palsy and non-cerebral palsy patients

Heel pressure injury	Sponge-incorporated cast	Multilayer padding cast	P-value
At 2 weeks (n=10)			
Cerebral palsy	3	3	0.662
Non cerebral palsy	1	3	0.333
At 4 weeks (n=12)			
Cerebral palsy	0	3	0.276
Non cerebral palsy	6	3	0.474

DISCUSSION

The use of sponge-incorporated casts and multilayer padding casts following elective surgery aimed to reduce the incidence of cast-related heel pressure injuries. We compared the incidence of cast-related heel pressure injuries in pediatric patients between sponge-incorporated long leg casts and multilayer padding long leg casts following elective surgery. The incidence of heel pressure injuries in the sponge-incorporated long leg cast group was 8.7% at two weeks and 13% at four weeks of follow-up. In the multilayer padding cast group, the incidence was 11.1% at both two weeks and four weeks of follow-up. There were no statistically significant differences between the groups at either time point.

Previous studies have described several techniques to reduce the incidence of pressure injuries.[6,8-12] Murgai et al.[1] conducted a retrospective study of foam padding in postoperative lower extremity casting and reported a reduced incidence of heel pressure injuries from 4.3% to 0.9%. DiFazio et al.[8] showed a reduction in cast-related skin complications with the placement of felt padding at the heel inside lower extremity casts from 17.1 per 1,000 casts to 6.8 per 1,000 casts. Forni et al.[9] also demonstrated a significant reduction in the incidence of pressure sores with polyurethane foam placed at the heel during lower extremity cast application in patients that underwent chemotherapy or patients who were presented with heel soreness. Our study was the first randomized controlled trial to compare the incidence of heel pressure injuries in long leg casts among pediatric orthopedic patients who underwent soft tissue surgery procedures. We controlled the padding technique using either sponge or 5 layers of Webril®. Both techniques were comparable in preventing heel pressure injuries.

We classified the stage of heel pressure injury using the 2016 NPUAP pressure injury staging system.[7,13] We found that the incidence of heel pressure injuries in our study was higher than in previous studies. This outcome is based on the pediatric population in this study, which had less ambulation during the casting period. Some patients had long leg casts bilaterally, and some patients had neurological problems, making it difficult for them to use gait aids. Most patients with heel pressure injuries in both the sponge-incorporated long leg cast and multilayer padding cast groups were at stage 1. Pressure injuries mainly occurred at the heel, but a few were found at the ankle, thigh, foot, or knee, similar to previous reports.[1,8,9]

Cast-related pressure injuries occur at areas of increased pressure underneath the cast, leading to decreased perfusion, ischemia, and necrosis. These areas of localized tissue injury usually occur over bony prominences where there is minimal muscle and adipose tissue overlying the bone, leaving these areas susceptible to impaired circulation. Pressure injuries commonly occur in patients who do not mobilize well. Long leg casts impair mobility, and impairment in mobility prevents patients from relieving pressure by movement or changes in body position, increasing the risk for pressure ulcer formation. Patients with static encephalopathy, spasticity, difficulty communicating and expressing pain, high BMI, and poor nutrition are also at increased risk of pressure injuries.[1,7,8]

Our study has some limitations. First, we included patients who underwent soft tissue surgery, so the results may vary in other bony procedures. Second, this study involved three pediatric orthopedic surgeons, which could result in variations in techniques. Future studies may include non-operative patients and other bony procedures.

CONCLUSION

The incidence of cast-related heel pressure injury was comparable between sponge padding cast and a multilayer cotton padding cast.

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Author contributions

P.E. designed the study and collected the data. T.L. involved in data collection, analysis of data and did manuscript drafting. C.C., T.A. and J.W. wrote the paper in the aspect of review and edited the manuscript. T.L. and P.E. provided final approval of the manuscript version submitted.

DECLARATIONS

Ethics approval and consent to participate

The institutional review board (IRB) and departmental data safety monitoring board (DSMB) approved and monitored this study.

Consent for publication

Informed consent was obtained from all parents included in this study.

Competing interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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