นิพนธ์ต้นฉบับ | Original Articles

การศึกษาความเที่ยงตรงและความแม่นยำของการวัดมุมแอ่นของกระดูกสันหลังส่วนเอวด้วยการใช้โปรแกรมจากโทรศัพท์มือถือเทียบกับการวัดโดยใช้โปรแกรมวัดระบบ Picture Archiving and Communication System (PACS)

A Comparative Study of the Accuracy and Reliability of Lordosis Lumbar Spine Measurement Using a Mobile Phone Application and a Picture Archiving and Communication System (PACS)

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บทคัดย่อ

หลักการและเหตุผล : มุมแอ่นกระดูกสันหลังช่วงเอวเป็นพารามิเตอร์ที่สำคัญสำหรับการผ่าตัดกระดูกสันหลัง อย่างไรก็ตาม ศัลยแพทย์ส่วนใหญ่ใช้การประเมินโดยการประมาณจากการดูภาพถ่ายจากเครื่องฟลูออโรสโคปี้ระหว่างผ่าตัดซึ่งขาดความแม่นยำ ทางคณะผู้วิจัยจึงพัฒนาเทคนิคคอบบ์เตอร์ วิธีใหม่ซึ่งช่วยให้การวัดมุมง่ายขึ้นเพียงอาศัยแอปพลิเคชั่นที่ติดตั้งมาแล้วในสมาร์ทโฟน

วัตถุประสงค์ : เพื่อเปรียบเทียบความแม่นยำและเที่ยงตรงของเทคนิคคอบบ์เตอร์เทียบกับมาตรฐานการวัดมุมภาพถ่ายรังสีโดยใช้เครื่องมือวัดมุมในระบบจัดเก็บรูปภาพทางการแพทย์ PACS (Picture Archiving and Communication System)

วิธีการศึกษา : เป็นการศึกษาย้อนหลังภาพถ่ายรังสีของผู้ป่วยซึ่งเข้ารับการผ่าตัดรักษาที่แผนกออโธปิดิกส์ โรงพยาบาลสุรินทร์ รังสีด้านข้างของกระดูกสันหลังส่วนเอวในท่ายืน ผู้วิจัย 2 คนวัดภาพถ่ายรังสีด้วยวิธีทั้ง 2 วิธีอย่างเป็นอิสระต่อกัน

ผลการศึกษา : ภาพถ่ายรังสีของผู้ป่วย 32 ราย ได้รับการวัดและวิเคราะห์ผล พบว่าวิธีคอบบ์เตอร์ไม่ได้มีความแตกต่างจากวิธีมาตรฐานผ่านระบบ PACS ในด้านความแม่นยำอย่างมีนัยสำคัญทางสถิติ (p=0.26) แม้ว่านำผู้ป่วยกลุ่มที่มุมแอ่นสูงมากกว่า 40 องศามาวิเคราะห์แยกส่วนแล้วก็ตาม (p=0.517) ผลการวิเคราะห์ความเที่ยงของวิธีคอบบ์เตอร์อยู่ในเกณฑ์ยอดเยี่ยม ทั้งความเชื่อมั่นระหว่างผู้ประเมิน (ICC=0.946) และความเชื่อมั่นเมื่อประเมินซ้ำ (ICC=0.998)

สรุป : วิธีวัดมุมด้วยเทคนิคคอบบ์เตอร์มีความแม่นยำและเที่ยงสูง สำหรับการวัดมุมแอ่นของกระดูกสันหลังส่วนเอว หากภาพถ่ายเป็นไปตามวิธีที่กำหนด สามารถใช้ได้ในทางคลินิก โดยเฉพาะในห้องผ่าตัดร่วมกับเครื่องฟลูออโรสโคปี้ อย่างไรก็ตาม หากจะนำไปใช้วัดมุมอื่นๆ เช่น มุมหลังคด อาจจะต้องทำการศึกษาเพิ่มเติมก่อนนำไปใช้

คำสำคัญ : มุมแอ่นกระดูกสันหลังช่วงเอว วัดมุมโดยใช้สมาร์ทโฟน ระบบจัดเก็บรูปภาพทางการแพทย์ คอบบ์เตอร์ มุมโค้งกระดูกสันหลัง

ABSTRACT

Background : Lumbar lordosis angle is a critical parameter for spinal surgeons to achieve optimal outcomes during surgery. However, traditional fluoroscopic imaging lacks built-in tools for accurate angle measurement, prompting surgeons to rely on subjective estimations. This study introduces the "Cobbter technique," a novel method employing a smartphone camera for objective lordosis angle measurement.

Objective : We aimed to compare the accuracy and reliability of the Cobbter technique against the Pictures Archiving and Communication system (PACS) angle measuring tool, a gold standard in clinical settings.

Methods : We retrospectively analyzed patients undergoing lateral lumbosacral radiography at Surin Hospital's orthopedic department. Two independent investigators measured the lordosis angle using both the Cobbter technique (CT) and the PACS tool (PT).

Results : The study included 32 lateral lumbosacral radiographs. The Cobbter technique demonstrated no statistically significant difference compared to PACS measurements (p=0.26). Subgroup analysis in patients with hyperlordosis (> 40 degrees) further confirmed this equivalence (p=0.517). Notably, the CT method exhibited excellent inter-observer (ICC=0.946) and intra-observer (ICC=0.998) reliability.

Conclusion : The Cobbter technique offers a valid and reliable alternative for measuring lordosis angle, particularly when appropriate imaging protocols are followed. Future studies should explore its applicability to other spinal parameters like scoliosis angles.

Keywords : Lumbar lordosis, Mobile phone application, PACs, Cobbter, Lordosis angle.

Introduction

As humans evolved to stand upright using their two legs, a lordotic curvature developed in the lumbar spine to facilitate balance and posture.[1-2] This curvature exhibits individual variations and changes with spinal degeneration.[1-6] The Cobb angle serves as the standard method for measuring this curvature, utilizing a goniometer or angle measurement software within the Picture Archiving and Communication System (PACS).[7-13]

A primary objective in degenerative spinal correction surgery is to restore the lumbar lordosis angle to the patient's original anatomy.[2-6,14-16] However, intraoperative assessment of this angle often relies on visual estimation of fluoroscopic images without precise angle measurement. In many centers, the fluoroscopy lacks integrated angle measurement tools, and the use of goniometers introduces complexity due to the requirement for instruments which are often unavailable

in the operating room.[7,9,10,17] Consequently, angle estimation relies heavily on surgeon experience and visual judgment.

To address these limitations, the researchers developed a novel angle measurement technique utilizing the widely available tool in the past two decades: the smartphone camera with built-in image editing application. The so called "Cobbter technique", an innovative method employing image rotation to measure the angle like a helicopter blade and incorporates Cobb angle principles. The objective of this study is to compare the accuracy and reliability of this novel method against the established standard.

Material and methods

Patient Population:

The study included patients admitted to the spine unit of the orthopedic department at Surin Hospital between January 2023 and December 2023. after receiving approval from the ethic committee of Surin hospital with reference number 33/2567. Inclusion criteria were patients who diagnosed with spinal disease underwent anteroposterior (AP) and lateral radiographs of the lumbosacral spine (T12-S1). Exclusion criteria were inadequate radiograph quality, lumbosacral transitional vertebrae, blurre or irregular L1 or S1 vertebral endplates, and scoliosis angle exceeding 10 degrees (potentially affecting lordotic angle measurement). Demographic data (age, gender, disease diagnosis, scoliosis angle) were collected.

Imaging and Measurement Techniques:

All radiographs were archived within the INFINITT PACS system. The lordotic angle was measured utilizing the upper endplates of L1 and S1 as reference points.[4,11–13]

- **PACS Angle Measuring Tool (PT):** Angle measurement tool in PACS were used. The first line was made parallel to the upper endplate of L1 vertebral body. The second line was made parallel to the upper endplate of S1 vertebral body. The built-in program automatically calculated the angle in two decimal units.
- **Cobbter Technique (CT):**

o **Image Acquisition:** A standardized protocol was followed for capturing radiograph images (Fig.1).

- iPhone 12 with iOS version 17.5.1 was used.
- Grid and level functions of the camera application were activated.
- The phone and monitor were positioned one foot apart.
- The center of the photograph aligned with the L3 vertebral body center.
- All four sides of the camera were maintained parallel to the corresponding sides of the monitor or radiograph.

o Image Processing: After capturing the image, the cropping function of the photo editing tool was used.

- The "straighten" function was applied.
- The image was rotated until the upper endplate of S1 paralleled to one of the horizontal lines of the grid, with the displayed angle designated as "A" (Fig.2).
- Subsequently, the image was rotated to make the horizontal line of the grid parallel to the upper endplate of L1, with the displayed angle designated as "B" (Fig.3).
- The lordotic angle of lumbar spine was calculated as "A minus B".

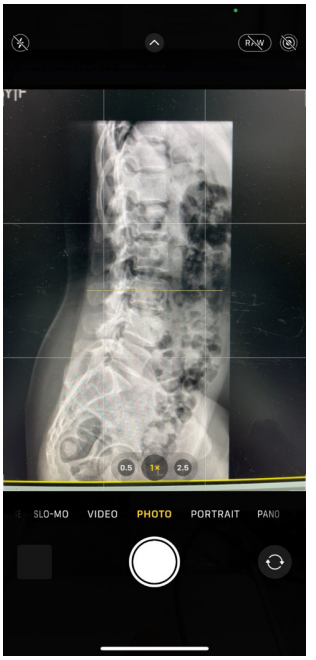

Fig.1 Protocol for taking the picture to measure with Cobbter technique

Fig.2 While using "Crop" tool and select "Straighten" function, align S1 upper vertebral endplate with an adjacent horizontal line of the grid. The value show in the circle is "A" angle.

Fig.3 After measuring A value, rotate the film to make L1 upper vertebral endplate to parallel with the grid's horizontal line. The angle show in the circleis "B".

Measurement Reliability:

Two independent researchers (NT and SK) measured the radiographs using both techniques subsequently. Researcher NT repeat the process after a 15-day washout period to minimize bias.

Statistical Analysis:

Statistical analysis was performed using SPSS (IBM Version 28.0.1.0 [142]). A clinically significant difference was defined as a mean deviation exceeding 4.5 degrees, according to Panjabi M.[16] Statistical significance was set at $p < 0.05$. Paired t-tests were used to compare the accuracy of CT with PT as the reference standard. Intraclass correlation coefficients (ICC) assessed inter- and intra-observer reliability of the CT method.

Results

A total of 32 patients were included in the final analysis. Sixteen patients were excluded due to:

- Inadequate radiograph quality (n=8)
- Scoliosis angle exceeding 10 degrees (n=5)
- Blurred vertebral endplates (n=2)
- Lumbosacral transitional vertebra (n=1)

The mean age of the included patients was 58.4 years (range 43-78 years). Females comprised 65.6% (n=21) of the cohort. Diagnoses included:

- Degenerative spinal stenosis (n=23, 71.9%)

• Degenerative spondylolisthesis (n=5, 15.6%)

• Herniated nucleus pulposus (n=4, 12.5%)

The difference between lordotic angle measurements obtained using the Cobbter technique (CT) and the PACS angle measuring tool (PT) was not statistically significant (Table 1). Subgroup analysis of patients with hyperlordosis also revealed no statistically significant differences between the two methods (Table 2). No patient displayed a difference exceeding the predefined clinically significant threshold of 4.5 degrees.

Both methods demonstrated excellent inter-observer reliability (PT: ICC = 0.970, CT: ICC = 0.946). Similarly, intra-observer reliability was excellent for both techniques (PT: ICC = 0.997, CT: ICC = 0.998).

Table 1. Comparison between PACS measurement and Cobbter technique by two independent investigators

	PACS measurement	Cobbter	Paired differences	p-value
Investigator 1*	35.72±14.00	36.22±14.35	-0.49±2.40	0.260
Investigator 2†	34.98±13.27	35.09±13.35	-0.11±1.28	0.630
Investigator 2 (repeat)	34.90±13.28	35.00±13.47	-0.10±0.99	0.560

*Investigator 1=SK

†Investigator 2=NT

Table 2. Subgroup analysis in patients with lumbar hyperlordosis to compare between PACS measurement and Cobbter technique by two independent investigators

Hyperlordosis	PACS measurement	Cobbter	Paired differences	p-value
Investigator 1*	48.40±6.63	48.85±8.03	-0.45±2.43	0.517
Investigator 2†	46.96±5.51	46.85±5.60	0.11±1.31	0.762
Investigator 2 (repeat)	46.76±5.43	46.90±5.25	-0.17±0.87	0.502

*Investigator 1=SK

†Investigator 2=NT

Discussion

Sagittal imbalance, characterized by an inability to maintain center of mass in the sagittal plane, is frequently associated with a loss of lumbar lordosis due to various etiologies.[2,5,6,16] Restoring normal lumbosacral alignment is a crucial surgical objective for regaining sagittal balance.[2-6,14,15] However, many centers, including ours, lack efficient methods for intraoperative measurement of the lumbar lordotic angle.

In response to this limitation, we developed the "Cobbter technique" to assist surgeons in determining the lordotic angle during surgery. This study demonstrates that

the established PACS angle measuring tool (PT) exhibits excellent inter-observer reliability, consistent with prior research.[7-9] Notably, the Cobbter technique (CT) yielded high accuracy compared to PT measurements performed by both investigators. Additionally, the CT method demonstrated excellent intra-observer reliability. Wu, et al.[10] study sagittal plane Cobb angle including lumbar lordosis using manual measurement compare with Surgimap Spine software in computer. Their findings suggest that the software offered superior reliability (ICC ranging from 0.71 to 0.08) compared to the manual method (ICC ranging from 0.50 to 0.96). However, it is important to note the significant variability observed in the manual measurement reliability (ICC 0.50 to 0.96). Our technique demonstrates consistently high interobserver reliability.

The Cobbter technique offers several advantages:

- **Accessibility:** The widespread use of smartphones in the current era ensures easy access to the technology.[17]
- **Ease of Use:** The technique utilizes built-in smartphone applications, eliminating the need for additional app downloads. Additionally, the procedure requires only a few steps, facilitating rapid learning.
- **Image-Based Measurement:** The CT method measures angles directly from captured images, eliminating the need for physical radiographs within PACS.

The Cobbter technique has limitations:

- **Protocol Dependence:** Achieving high accuracy necessitates adherence to a specific image capture protocol.
- **Angle Measurement Range:** The current application limits measurement to angles below 90 degrees.
- **Decimal Precision:** Inability to measure in decimal units restricts its application in research settings.

Previous studies of using smartphones for scoliosis Cobb angle measurement focus primarily on scoliosis Cobb angle measurement. Ketenci et al.[17] compared PACS with two other applications: iPinPoint and Cobbmeter. Those two applications show high interobserver and intraobserver reliability (ICC iPinPoint=0.980, ICC Cobbmeter=0.991). Shaw et al.[18] using an iPhone protractor application compared it with a standard protractor. They concluded that both methods showed equivalent results when measuring scoliosis angle.

Future investigations should explore the applicability of the Cobbter technique to other spinal parameters, such as scoliosis angle measurement. Expanding the angular measurement range and achieving decimal precision should also be prioritized for broader clinical and research utility.

Conclusion

The present study demonstrates that the Cobbter technique offers a valid and reliable alternative for measuring the lumbar lordosis angle during surgery, particularly when adherence to a standardized image acquisition protocol is ensured. The widespread availability of smartphones empowers point-of-care assessment using this technique, potentially improving surgical decision-making for optimal spinal alignment restoration. While the current limitation lies in the inability to measure in decimal units, future research should explore the applicability of the Cobbter technique to other spinal parameters such as scoliosis angles, along with investigating methods to expand

its angular measurement range and achieve decimal precision for broader clinical and research utility.

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