Original Article

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Reliability of the Sundsvall Method for Femoral Offset Evaluation

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Purpose: Acetabular and femoral offset (FO) play an important role in total hip arthroplasty (THA). The Sundsvall method has been proposed to account for both FO and cup offset in one global hip offset measurement. In this study, we examine the agreement and inter-observer reliability of the Sundsvall method of hip offset measurement.

Materials and Methods: Four hundred and ninety-nine THA patients at a single tertiary academic institution were retrospectively reviewed. Preoperative hip offset was measured on anteroposterior radiographs of the pelvis on the operative and contralateral side. Hip offset was also measured postoperatively on the operative side. Hip offset was measured using the Sundsvall method as the distance between the femoral axis and midline of the pelvis at the height of the lateral most point of the greater trochanter. All measurements were completed by two raters. Intra-class correlation coefficients (ICC) and Pearson's correlation coefficients were used to evaluate agreement and inter-observer reliability between two raters.

Results: There was excellent agreement between raters for preoperative hip offset measurement with an ICC of 0.91 (confidence interval [CI] 0.90-0.93, $P<0.01$) and R=0.92. There was excellent agreement between raters for postoperative hip offset with an ICC of 0.93 (CI 0.92-0.94, $P<0.01$) and R=0.93.

Conclusion: This study confirms the inter-observer agreement and reliability of the Sundsvall method of hip offset measurement. With its high agreement and reliability, the Sundsvall method is an easy and reliable way to measure hip offset that can be applied in future clinical and research settings.

Keywords: Pelvis, Arthroplasty, Replacement, Hip, Reproducibility of results

INTRODUCTION

The goal of total hip arthroplasty (THA), a widely performed surgical procedure, is to restore joint function and alleviate pain in patients with hip joint degeneration. Measurements of acetabular and femoral offset (FO) are critical in achieving optimal positioning of the implant and ensuring biomechanical stability[1,2]. FO and acetabular offset have traditionally been measured separately, potentially resulting in differences in surgical planning and outcomes[3,4]. Femoral offset is defined as the perpendicular distance from the center of rotation (COR) of the femoral head to the axis of the femur[1]. However, in THA reaming and cup implantation can cause changes to the acetabular COR. Therefore, FO no longer represents displacement of the femur from the pelvis—displacement is influenced by both FO and cup COR (two authors have termed this change in cup COR as "cup offset")[3,4]. The Sundsvall method has been proposed as a comprehensive solution to account for both FO and cup offset in a single global hip offset measurement[5].

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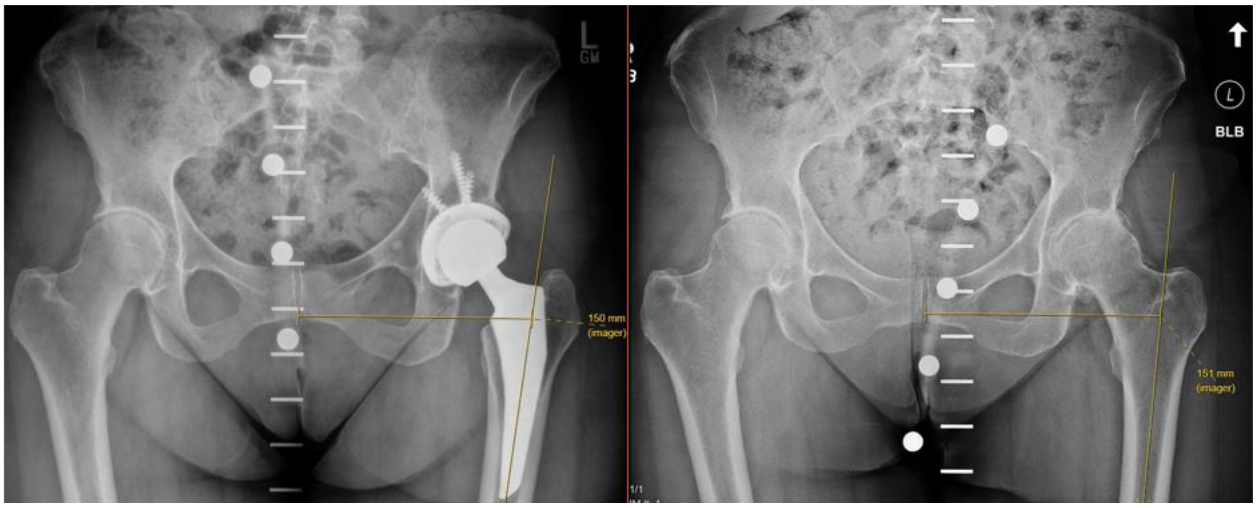

Fig. 1. The Sundsvall method for measuring hip offset from pelvic midline bisecting the femoral axis at the level of the lateral most aspect of the greater trochanter.

Accurate and reliable measurement of hip offset is essential for proper selection and positioning of implants. Use of the Sundsvall method can enable a unified measurement of femoral and acetabular offset. It measures a line from the midpoint of the pubic symphysis bisecting the femoral axis at the height of the lateral most point of the greater trochanter[5] (Fig. 1). Interest in this method has increased due to its potential to improve the accuracy and reproducibility of hip offset measurements in THA[6].

Knowledge regarding the reliability of the Sundsvall method is essential for its potential assimilation into routine clinical practice. The objective of this study is to examine the agreement and inter-observer reliability of the Sundsvall method for measurement of hip offset in patients who underwent THA. Examining the inter-observer agreement can be helpful in determining the reliability of this method for measuring hip offset in THA. The findings of this study will contribute to the current body of knowledge on techniques for measurement of hip offset and provide insights for consideration in future clinical and research applications in the field of THA.

MATERIALS AND METHODS

The Institutional Review Board (IRB) was reviewed by the Duke University IRB who determined that it was eligible for exemption. The study was conducted according to the guidelines of the Declaration of Helsinki (2013). This study was a retrospective review that blinded patient identifying data, informed consent was not obtained. All THA cases performed using a primary direct anterior approach within a tertiary healthcare system between January 2016 and March 2022 were identified through conduct of a retrospective review. Inclusion criteria were patients who underwent a primary THA performed using a direct anterior approach and had preoperative and postoperative anteroposterior (AP) radiographs of the pelvis. Patients who had undergone revision hip arthroplasty or patients without appropriate preoperative and postoperative radiographs were excluded.

A total of 452 patients were included in the study and 47 patients underwent bilateral THAs during the study period, resulting in inclusion of 499 hips in our analysis. Demographic information including age at time of surgery and sex were recorded for each patient. Preoperative and postoperative hip offset were measured on the operative side on AP radiographs of the hip and on the contralateral side on preoperative radiographs using the previously described Sundsvall method (Fig. 1). A subset of patients had undergone previous THA performed on the contralateral side without available preoperative native imaging of the hip. Contralateral measurements of hip offset for these patients were based on their current THA offset.

Preoperative and postoperative hip offset were measured on the operative side on AP radiographs of the pelvis and on the contralateral side on preoperative radiographs. Measurement of hip offset was performed using the Sundsvall method, defined as the distance

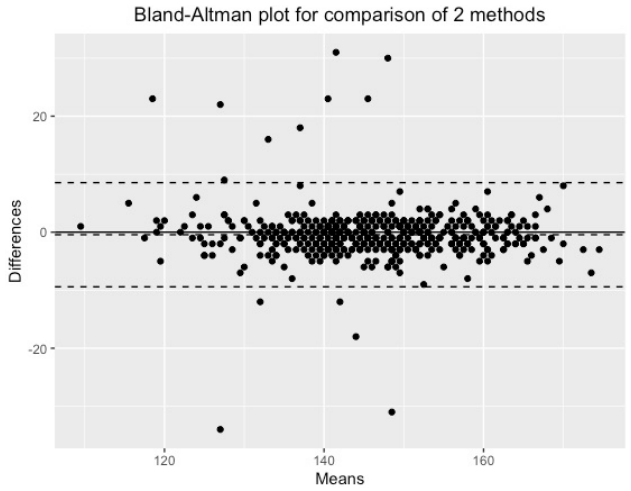

Fig. 2. Bland–Altman plot representing preoperative hip measurements.

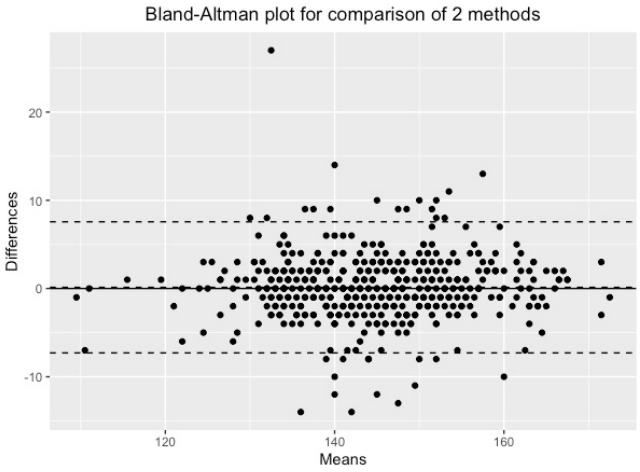

Fig. 3. Bland–Altman plot representing postoperative hip measurements.

between the femoral axis and midline of the pelvis at the height of the lateral most point of the greater trochanter. All measurements were performed by two raters at different time-points, and each rater was blinded to the other rater's measurement. Radiographs with institutional standardized markers were used to improve the accuracy of measurements. Intra-class correlation coefficients (ICC) and Pearson's correlation coefficients (R value) were used for evaluation of agreement and inter-observer reproducibility between two raters. ICC and Pearson's correlation coefficients were calculated using a standard method to determine reliability as demonstrated by Koo and Li[7]. All statistical analysis was performed using Microsoft Excel 2016 (Microsoft).

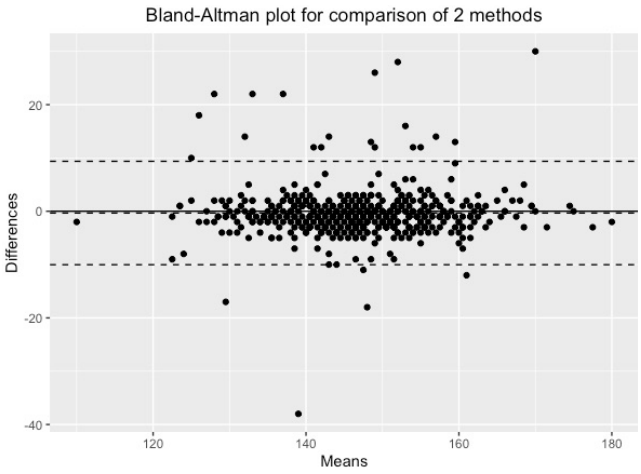

Fig. 4. Bland–Altman plot representing contralateral hip measurements.

Table 1. Intra-class Correlation Coefficients (ICC) in Preoperative, Postoperative, and Contralateral Hip Radiographs

	ICC value	Confidence interval	*P*-value	R value
Preoperative (n=499)	0.91	0.90-0.93	<0.01	0.92
Postoperative (n=499)	0.93	0.92-0.94	<0.01	0.93
Contralateral (n=499)	0.89	0.86-0.90	<0.01	0.89

RESULTS

There were 264 female patients and 188 male patients. The mean age of patients in the cohort was 58 years (range, 19-92 years). The results showed excellent agreement between raters for measurement of preoperative hip offset on the operative hip with an ICC of 0.91 (confidence interval [CI] 0.90-0.93, P<0.01) and R=0.92. The results showed excellent agreement between raters for postoperative hip offset on the operative hip with an ICC of 0.93 (CI 0.92-0.94, P<0.01) and R=0.93. The results showed good agreement between raters for contralateral hip offset with an ICC of 0.89 (CI 0.86-0.90, P<0.01) and R=0.89. Fig. 2-4 show the Bland–Altman plots, which provide a graphical representation of the reliability of preoperative, postoperative, and contralateral hip measurements. These data are also shown in Table 1.

DISCUSSION

Measuring hip offset is critical for preoperative, intraoperative, and postoperative planning and evalua-

tion of THA[8-10]. Many methods have been proposed for measuring FO, acetabular offset, and global hip offset on both plain radiographs and advanced imaging. The Sundsvall method offers a technique for measuring global hip offset on an AP radiograph. The objective of this study was to assess the reliability of this method in measuring global hip offset. Our findings demonstrated the reliability of the Sundsvall method with excellent ICC. Definitions of excellent and good agreement are based on guidelines proposed by Koo and Li[7] for interpreting ICC with >0.90 considered excellent and 0.80-0.90 considered good agreement.

Dastane et al.[1] reported on correlation of hip offset in arthritic hips with cup COR using navigation, demonstrating a direct relation of hip offset reconstruction to the position of the hip COR, which could be quantified using navigation. Cassidy et al.[9], who measured the effects of FO and the change following THA compared to the contralateral normal hip, provided a similar description of the importance of hip offset in THA. They categorized patients according to three groups: those with decreased offset (<–5 mm compared to contralateral normal), those with normal offset (–5 mm to +5 mm), and those with increased offset (>5 mm). Lower Western Ontario and McMaster University Osteoarthritic Index Physical Function scores were observed for patients with decreased offset compared to those with normal and increased offset. This finding illustrates the importance of quantifying offset as it correlates with a patient's scores for physical function. However, evaluating the reproducibility of the measures first is critical for correlating offset measurements with patient outcomes.

The Sundsvall method was originally described by Kjellberg et al.[5] for evaluation of hip offset on AP radiographs of the pelvis using the pelvic midline and the femoral axis for measurement of global hip offset in pre- and postoperative THA radiographs. Mahmood et al.[6], who evaluated the Sundsvall method for measurement of FO as well as leg length discrepancy, acetabular cup inclination, and anteversion in a retrospective review of 90 patients with primary unilateral osteoarthritis, reported good inter-observer reliability and intra-observer reproducibility (ICC>0.80) using the Sundsvall method, and concluded that the Sundsvall method can be regarded as a reliable and valid method for measuring FO. This study was conducted at Sundsvall Teaching Hospital, which raises concern regarding confirmation bias. The current study is the first independent evaluation of this method showing excellent reliability in measuring hip offset on AP radiographs of the pelvis.

Work by Mahmood et al.[6], who attempted to confirm the reliability and reproducibility of their own method for measuring offset, demonstrated the reliability of the Sundsvall method in a smaller cohort. In comparison, one of the strengths of the current study is the number of hips examined, the independent nature of our study, and the use of both standing and supine radiographs. This ensures a well powered study and confirms the findings reported by Mahmood et al.[6] as our results also showed excellent ICC. The validation of the Sundsvall method suggests its potential usefulness in clinical practice for preoperative, intraoperative, and postoperative measurement of hip offset during planning, performance, and evaluation of THA[5,6,8].

One limitation of this study is that we decided to omit intra-observer measurements. The objective of this study was to determine the reliability between two independent observers so that this method can be utilized with confidence in conduct of future study of hip offset in THA. This study also includes a wide array of hip pathology from hip dysplasia, avascular necrosis to primary osteoarthritis. Considering the large sample size, our data suggest that despite the differing pathologies, the Sundsvall method still shows excellent reliability. Supine and standing radiographs were also used, and regardless of patient position, the results still indicated excellent reliability.

CONCLUSION

Overall, this is the first independent study confirming the reliability of the Sundsvall method for measuring hip offset in THA candidates, thus, the findings of this study add to the literature. The Sundsvall method can be used for surgical planning, intraoperative placement of a prosthesis, and postoperative evaluation of THA. It can also be regarded as a useful tool for conduct of future research on hip offset in THA.

Funding

No funding to declare.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Dastane M, Dorr LD, Tarwala R, Wan Z. Hip offset in total hip arthroplasty: quantitative measurement with navigation. Clin Orthop Relat Res. 2011;469:429-36. https://doi.org/10.1007/s11999-010-1554-7
2. Johnston RC, Brand RA, Crowninshield RD. Reconstruction of the hip. A mathematical approach to determine optimum geometric relationships. J Bone Joint Surg Am. 1979;61:639-52. https://doi.org/10.2106/00004623-197961050-00001
3. Kurtz WB, Ecker TM, Reichmann WM, Murphy SB. Factors affecting bony impingement in hip arthroplasty. J Arthroplasty. 2010;25:624-34.e1-2. https://doi.org/10.1016/j.arth.2009.03.024
4. Loughead JM, Chesney D, Holland JP, McCaskie AW. Comparison of offset in Birmingham hip resurfacing and hybrid total hip arthroplasty. J Bone Joint Surg Br. 2005;87:163-6. https://doi.org/10.1302/0301-620x.87b2.15151
5. Kjellberg M, Englund E, Sayed-Noor AS. A new radiographic method of measuring femoral offset. The Sundsvall method. Hip Int. 2009;19:377-81. https://doi.org/10.1177/112070000901900413
6. Mahmood SS, Al-Amiry B, Mukka SS, Baea S, Sayed-Noor AS. Validity, reliability and reproducibility of plain radiographic measurements after total hip arthroplasty. Skeletal Radiol. 2015;44:345-51. https://doi.org/10.1007/s00256-014-2055-7
7. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J Chiropr Med. 2016;15:155-63. https://doi.org/10.1016/j.jcm.2016.02.012
8. Mahmood SS, Mukka SS, Crnalic S, Wretenberg P, Sayed-Noor AS. Association between changes in global femoral offset after total hip arthroplasty and function, quality of life, and abductor muscle strength. A prospective cohort study of 222 patients. Acta Orthop. 2016;87:36-41. https://doi.org/10.3109/17453674.2015.1091955
9. Cassidy KA, Noticewala MS, Macaulay W, Lee JH, Geller JA. Effect of femoral offset on pain and function after total hip arthroplasty. J Arthroplasty. 2012;27:1863-9. https://doi.org/10.1016/j.arth.2012.05.001
10. Liebs TR, Nasser L, Herzberg W, Rüther W, Hassenpflug J. The influence of femoral offset on health-related quality of life after total hip replacement. Bone Joint J. 2014;96-B:36-42. https://doi.org/10.1302/0301-620X.96B1.31530