A Simple Method to Minimize Limb Length Discrepancy and Restore Offset in Total Hip Arthroplasty

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ABSTRACT

Introduction: There are more than 20 different techniques to correct lower limb length discrepancy. The method evaluated in this study is based on a fixed pin in the iliac wing connected to a mobile gauge and another pin in the greater trochanter with which the reference is marked. The objective is to evaluate the reliability of this measurement device used during THA to restore lower limb length and femoral offset. **Materials and Methods:** Two groups were formed: Group A (patients who did not use the device) and Group B (patients who did use the device). Measurements were taken in the pre-surgery panoramic pelvic radiograph with the patient standing and three months later. **Results**: A sample of 80 patients was obtained, with 40 in each group. The difference in limb length could be corrected in each group, however the average correction achieved by both groups did not result in a statistically significant difference (p=0.07). However, when the variance in the correction of the difference in length of each group was examined, a statistically significant difference (p<0.001) was obtained. **Conclusions:** We can conclude that while this device, which serves as a more objective quantifiable measurement technique, does not guarantee a correction of the exact length discrepancy to 0 mm, it does allow us to work within a more dependable and safe range.
Keywords: Lower limb length discrepancy; total hip arthroplasty; hip gauge.
Level of Evidence: III

Método simple para minimizar la discrepancia en la longitud de las extremidades y restaurar el offset en la artroplastia total de cadera

RESUMEN

Introducción: Existen más de 20 técnicas diferentes para corregir la discrepancia de miembros inferiores. El método aquí se evalúa se basa en una clavija fija posicionada en el ala ilíaca asociada a un "calibre" móvil, con otra clavija con la que se marca la referencia en el trocánter mayor. **Objetivo:** Evaluar la confiabilidad de este dispositivo de medición usado durante la artroplastia total de cadera para restaurar la longitud del miembro inferior y el *offset* femoral. Materiales y Métodos: Se formaron dos grupos: grupo A con pacientes en quienes no se había usado el dispositivo y grupo B con pacientes en quienes sí se había usado el dispositivo. Se realizaron las mediciones en la radiografía panorámica de pelvis obtenida con el paciente de pie, antes de la cirugía y 3 meses después. Resultados: Se obtuvo una muestra de 80 pacientes (40 por grupo). Se logró corregir la discrepancia de la longitud de los miembros, pero no se hallaron diferencias estadísticamente significativas en la corrección promedio, entre ambos grupos (p = 0,07). Sin embargo, al analizar la varianza en la corrección de la discrepancia de la longitud de cada grupo se obtuvo una diferencia estadísticamente significativa (p <0,001). **Conclusiones:** Este dispositivo que permite una medición cuantificable más objetiva no asegura una corrección de la discrepancia de la longitud exacta a 0 mm, pero sí permite trabajar dentro de un rango más confiable y seguro.
Palabras clave: Discrepancia de longitud; artroplastia total de cadera; calibre de cadera.
Nivel de Evidencia: III

INTRODUCTION

Limb length discrepancy after total hip arthroplasty (THA) is a cause of poor functional outcomes and can lead to sciatic pain, back pain, abnormal gait, and patient dissatisfaction. It is also the most common reason for lawsuits against orthopedists in the United States.[1,2] In cases of hip osteoarthritis, the affected limb is usu-

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ally shorter and this is due to: 1) loss of cartilage thickness and bone loss (structural shortening), 2) soft tissue contractures, such as hip adduction and flexion deformity (apparent shortening), and 3) compensatory pelvic obliquity (apparent shortening), with the affected hemipelvis higher to avoid leg crossing due to the adducted position.[2] One of the goals of THA is to correct limb length discrepancy caused by structural shortening and soft tissue contractures.

The restoration of femoral offset is also essential to obtain a favorable functional outcome by retaining a hip abductor lever arm to promote implant stability and survival, as well as gait quality.[3]

Careful and thorough preoperative planning is a critical step in preventing limb length discrepancy after THA, but also various intraoperative considerations can help minimize it. Direct comparison of the lower limbs is a widely used technique, but interobserver and intraobserver variability is very wide because of patient position and surgical fields. About 20 different techniques have been published to help correct lower limb discrepancy, all using a stable pelvic landmark and a variable femoral landmark.[4]

The method under study is based on a fixed pin placed in the iliac wing, superior to the acetabulum, and at the level of the anterior superior iliac spine, which is connected to a mobile caliper, and another pin with which the reference is marked on the greater trochanter, from which the length and offset of the hip are controlled (Figure 1).

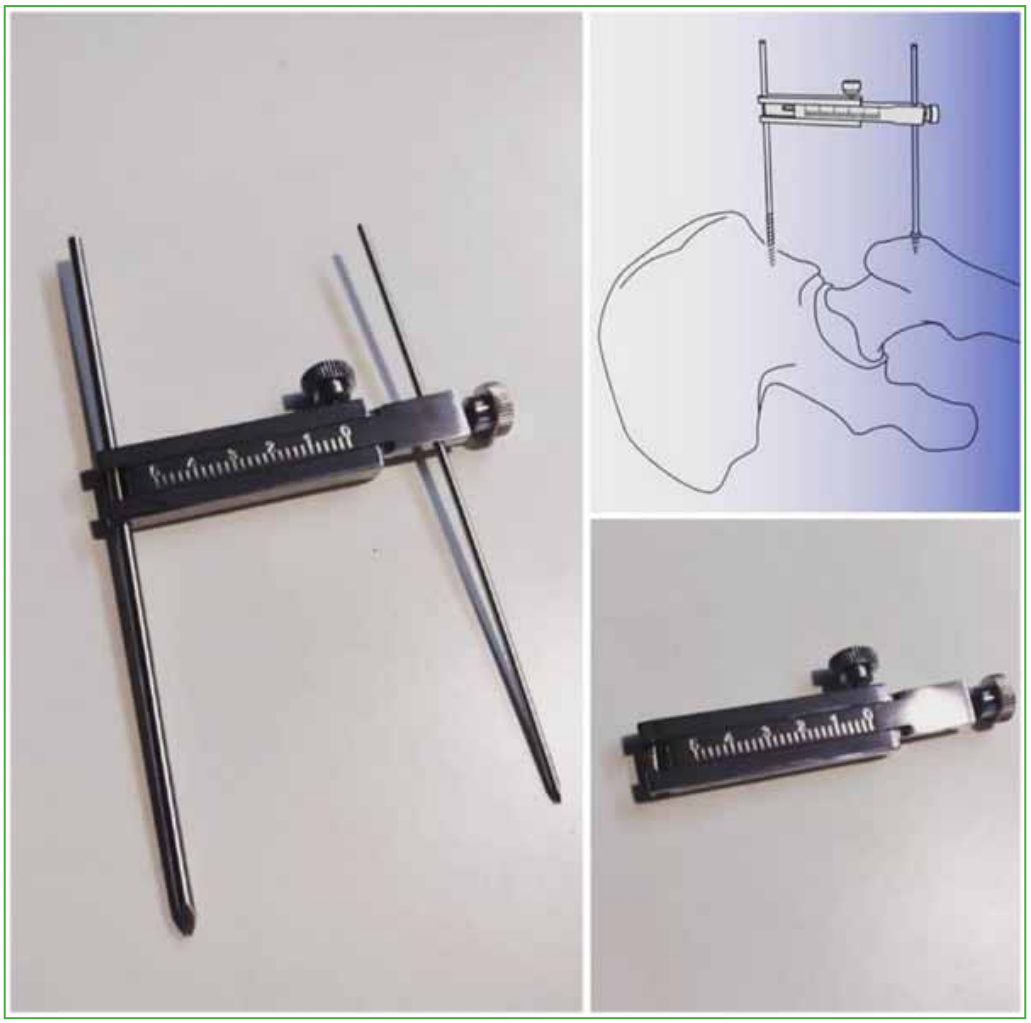

Figure 1. Limb length and femoral offset measuring device used during total hip arthroplasty.

OBJETIVE

To evaluate the reliability of a measurement device used during THA to restore lower limb length and femoral offset. This device, according to the working hypothesis, improves control of lower extremity length and offset.

MATERIALS AND METHODS

A retrospective, observational, longitudinal and analytical study was conducted. Inclusion criteria were: patients >18 years old with elective THA with radiographs at the preoperative period and three months after surgery. The following exclusion criteria were established: complex primary hip arthroplasty (e.g., dysplastic hip, ankylosed hip, fractures around the hip, acetabular protrusion, neuromuscular conditions, skeletal dysplasia, previous bone procedures on the hip), previous length discrepancy not attributable to hip disease, revision cases, tilted radiographs.

Patient demographic data were extracted from medical records. Two groups were formed, with a cutoff point in November 2019, at which time the use of the intraoperative measurement device began (Figure 2). Group A (control group) consisted of patients who had undergone THA before that date, without using this device, and group B (study group) included patients who underwent THA with the use of the measuring device after the aforementioned date.

Measurements were taken on the panoramic pelvis radiograph obtained with the patient standing, before surgery and three months after surgery.

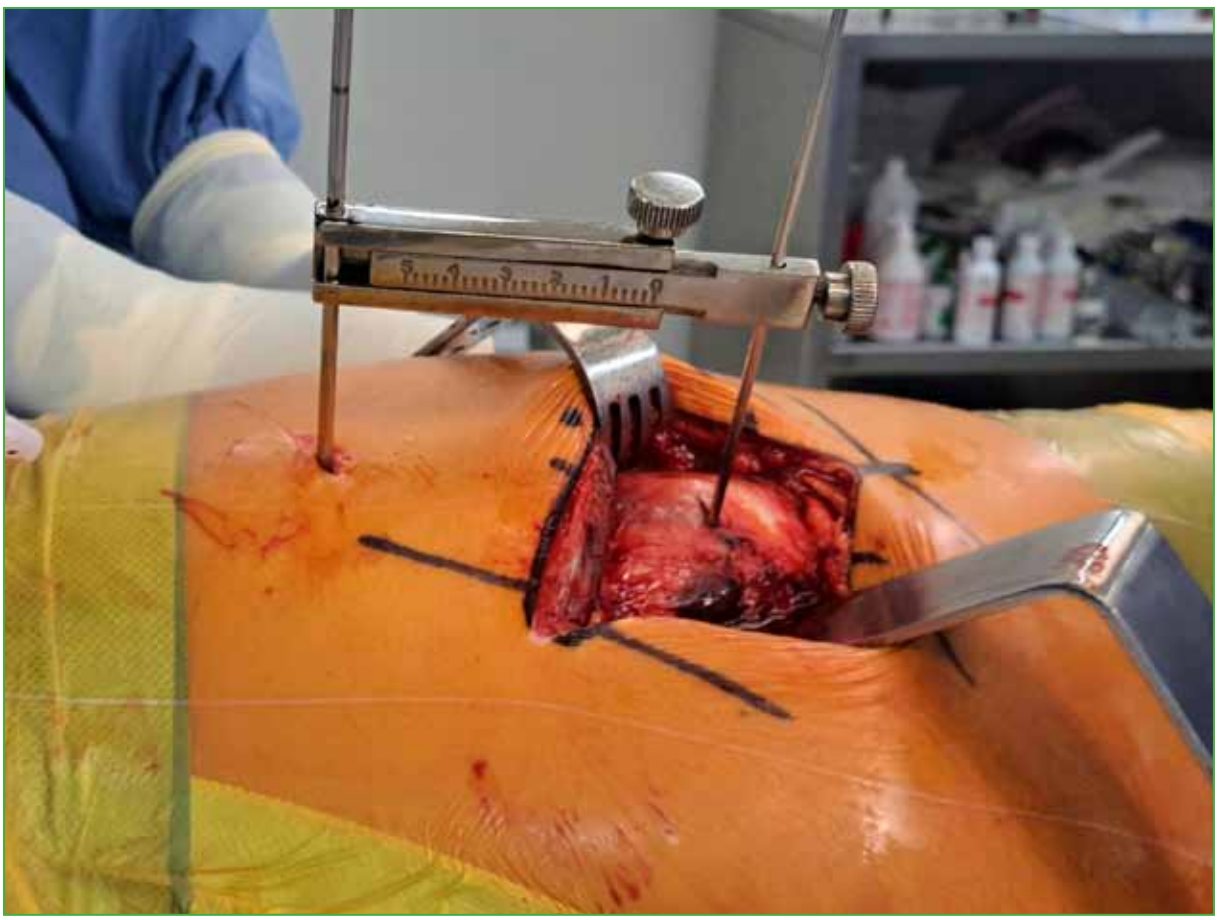

Figure 2. Intraoperative image of the use of the device. The mobile caliper is seen in association with two nails, one fixed in the iliac wing (left) and the other movable resting on a mark placed on the greater trochanter (right).

Limb length discrepancy was measured as the vertical distance between the pelvic reference line that connects the acetabular teardrops and the most prominent medial point of the lesser trochanter.[5] The length discrepancy with respect to the ipsilateral lower limb was measured on the preoperative radiograph, and the actual correction achieved with THA was measured on the postoperative radiograph. The result was recorded as a positive value to indicate lengthening of the operated leg or a negative value to indicate shortening.

All measurements were performed with the Windows MediCAD® program (Figure 3).

The research protocol was approved by the Institutional Ethics Committee and complies with the Declaration of Helsinki and the Declaration of Good Clinical Practices of the National Administration of Drugs, Food and Medical Technology (ANMAT). It also complies with Act 9694 of the Province of Córdoba and the Argentine National Personal Data Protection Act No. 25,326.

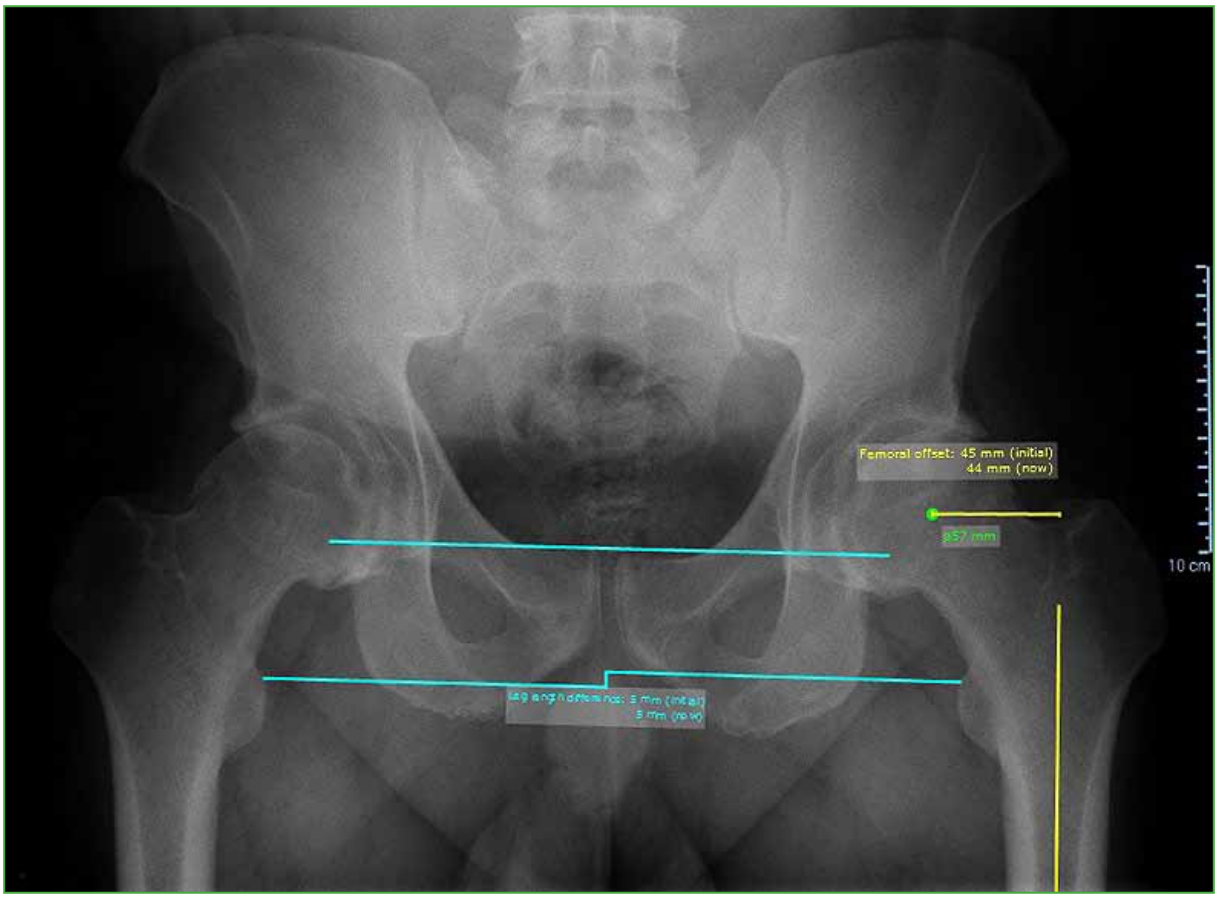

Figure 3. Example of measurements taken before surgery with the MediCAD® program.

Statistical Analysis

Demographic data were compared between the two groups using nonparametric Mann-Whitney and Kruskal-Wallis tests. Categorical variables (change in length and offset) are expressed as means, ranges, standard deviations and variances, and were analyzed with Spearman's exact correlation and Bartlett's homogeneity of variances tests for comparison between groups. The significance threshold was set at $p \leq 0.05$. The R-Medic program was used for the analysis.[6]

RESULTS

A sample of 80 patients was obtained, 40 in each group. Group A had an average age of 61.5 years, whereas Group B had an average age of 60.7 years. In both groups, male sex, right laterality, and osteoarthritis as preoperative diagnosis predominated, all without statistical significance (Table 1).

Table 1. Overall results for both groups

Variables		Without measuring device Group A (n = 40)	With measuring device Group B (n = 40)	p
Age (years)		61.5 ± 11.9	60.7 ± 11.3	0.83
Sex	Male	29 (72%)	23 (57%)	0.82
	Female	11 (28%)	17 (43%)	
Side	Right	21 (53%)	22 (55%)	0.97
	Left	19 (48%)	18 (45%)	
Diagnosis	Osteoarthritis	39 (98%)	38 (95%)	0.07
	Avascular bone necrosis	1 (2%)	2 (5%)	

In group A, the pathologic hip was, on average, 5.78 mm shorter before surgery, and a mean correction of 1.8 mm was achieved, resulting in an average postoperative difference of 3.98 mm (range -20 to +15 mm). 24% of the limbs operated on without the intraoperative measuring device were longer than the ipsilateral limb after surgery when compared with those in group B (10%).

In group B, the pathologic hip was, on average, 6.58 mm shorter before surgery, and a mean correction of 4.75 mm was achieved with surgery using the measuring device. The operated hip was, on average, 1.83 mm shorter (range -9 to +5 mm). In both groups, a statistically significant correction of limb length was achieved, but, when analyzing the average correction achieved between both groups after the operation, no statistically significant difference was found (p = 0.07) (Table 2, Figure 4).

Table 2. Comparative results between the two groups in the correction of length discrepancy and offset.

Variables		Group A Mean (SD)	Group B Mean (SD)	p
Length discrepancy	Preoperative	-5.78 (4.79)	-6.58 (4.8)	0.36
	Postoperative	-3.98 (8.17)	-1.83 (2.74)	0.07
	p	0.026	0.011	
Offset	Preoperative	45.30 (9.31%)	42.43 (8.60%)	0.19
	Postoperative	50.68 (6.78%)	48.63 (8.25%)	0.16
	p	0.001	0.001	

SD = standard deviation.

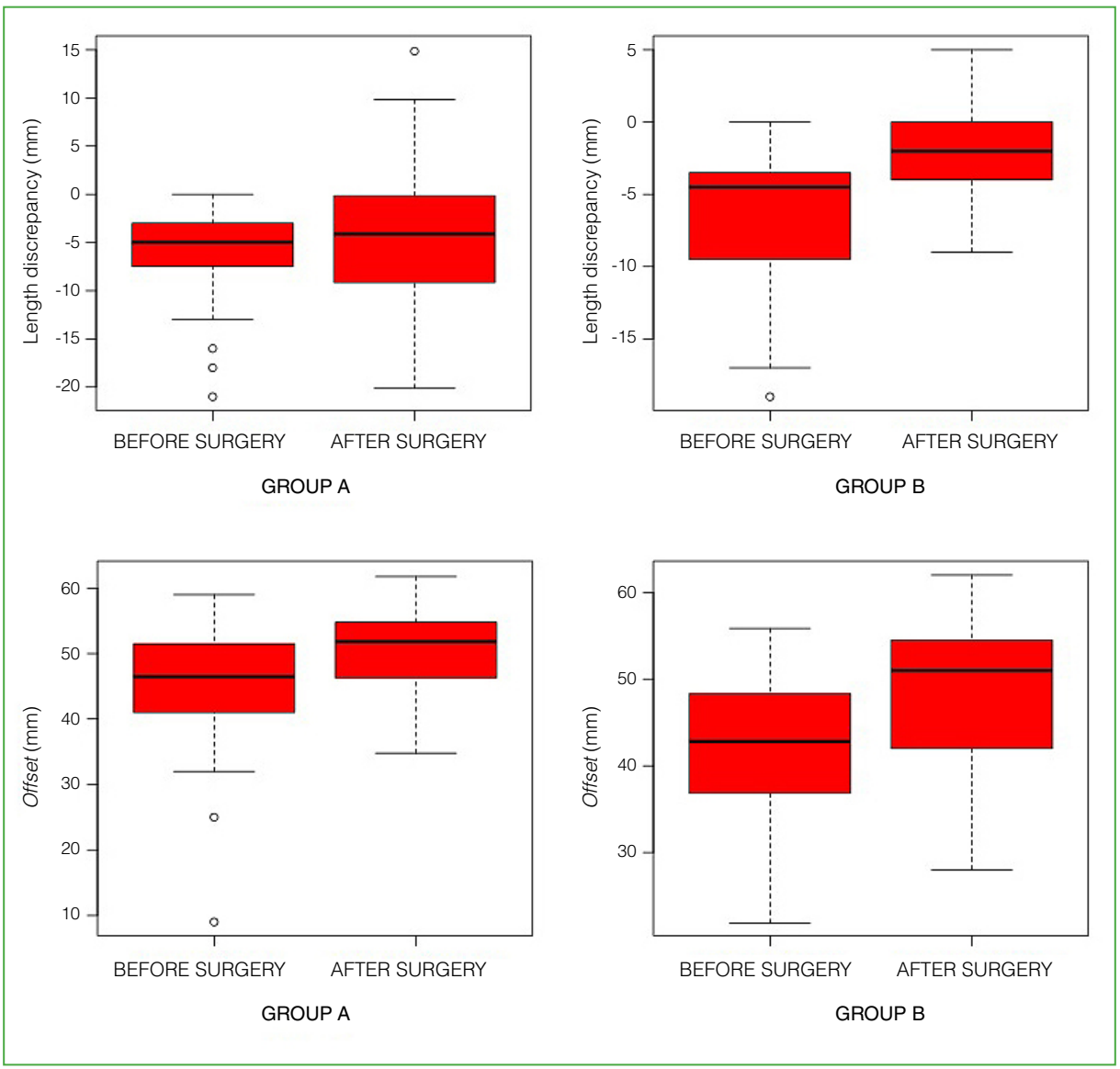

Figure 4. Box plot summarizing the values obtained before and after surgery, in both groups, with respect to length discrepancy and femoral offset.

However, when the variance in the length discrepancy correction of each group was analyzed, a statistically significant difference ($p<0.001$) was obtained (Figure 5).

The mean preoperative offset value in group A was 45.3 mm and increased to 50.68 mm after surgery, with an average increase of 5.38 mm, a statistically significant value. In group B, the average increase in femoral offset was 6.2 mm (42.43 mm preoperatively vs. 48.63), also with statistical significance. However, this increase in femoral *offset* was not statistically significant when comparing the two groups after surgery, nor was the variance in the results of the increase in femoral offset between the two groups significant (Figure 6).

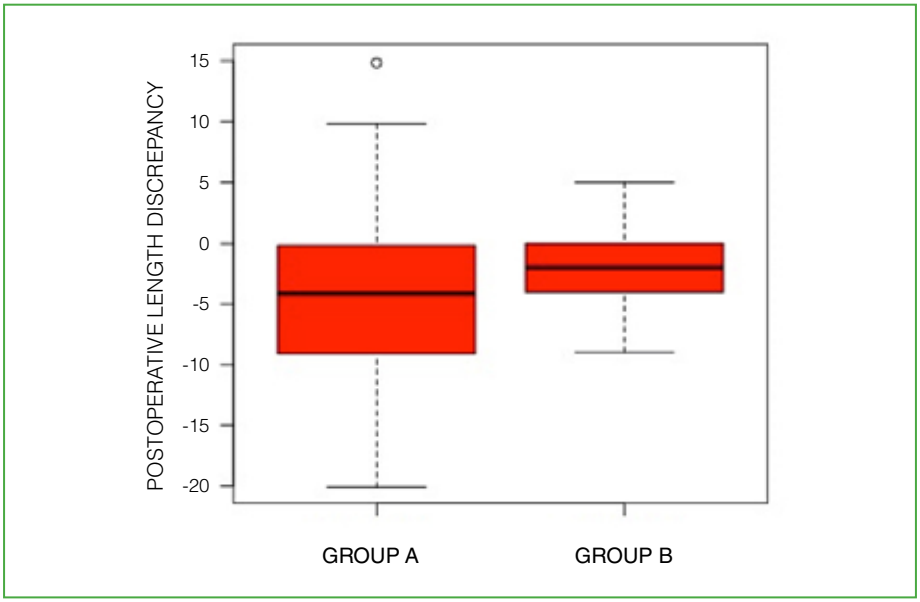

Figure 5. Box plot showing the statistical significance between the variances of each group in the length discrepancy correction ($p<0.001$).

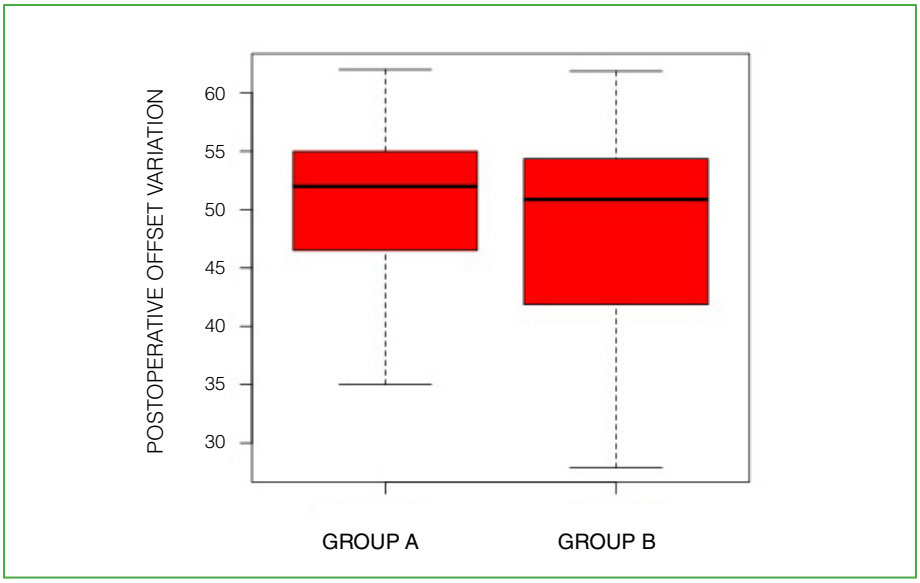

Figure 6. Box plot comparing the postoperative femoral offset of both groups, with no statistical significance in the mean or variance ($p = 0.23$).

DISCUSSION

One of the goals of THA is to accurately restore the length of the lower extremity and, at the same time, to achieve appropriate joint stability. This usually consists of maintaining the existing length or lengthening a shortened lower extremity. It is sometimes necessary to lengthen the lower limb to increase hip stability, because avoiding postoperative dislocation is more important than avoiding a length discrepancy, and it is generally accepted that lower limb length discrepancy is not fully corrected by THA and ranges from 1% to 27%,[7] with multiple causes.[8]

Many studies have been published describing intraoperative techniques for the management of leg length discrepancy. Matsuda et al.[9] obtained a smaller postoperative mean length discrepancy (2 vs. 7 mm) by measuring the distance between the center of the test femoral head and the lesser trochanter with a ruler and selecting the head and neck length closest to that planned before surgery. Using the same method, Gonzalez Della Valle et al.[10] obtained a length discrepancy <5 mm postoperatively in 90 of 103 hips.

The method evaluated here involves the use of a mobile caliper to measure the distance between two fixed points, one pelvic and the other femoral. The difference between the distance measured before dislocation and after trial reduction indicates the lengthening achieved.

This study demonstrated that the use of the intraoperative measuring device allowed a more accurate correction of the lower limb length discrepancy. In both groups, the trend was to leave the postoperative length shorter (on average, 3.98 mm shorter without the use of the caliper vs. 1.83 mm with the caliper). Although no significant difference was observed when examining the average correction attained in both groups, it is worth noting that statistical significance was reached when assessing the variance of each group, indicating that the extreme ranges of correction were narrower with the use of the caliper ($p < 0.001$). As a result, this device, which serves as a more objective measurement technique, does not guarantee a repair of the exact length disparity to 0 mm but does allow operating within a more dependable and safe range.

There was a tendency to leave the limb longer when the caliper was not used (group A: 24% vs. group B: 10%). Along these lines, Bose et al.[11] achieved lengthening >12 mm in 31% of hips without the use of the caliper versus 5% with the caliper, in a total of 117 surgeries.

Other studies have reported similar methods.[12-16] Most appear effective, but only concern limb length control and not offset. Woolson et al.[15] used a caliper attached to the iliac wing that ensured <6 mm discrepancy in 89% of patients. Ranawat et al.[13] used a Steinman nail placed in the ischium, at the inferior aspect of the posterior horn of the acetabulum, and the discrepancy was <6 mm in 87% of the cases. Konyves and Bannister[2] reported a mean discrepancy of 9 mm with a similar device.

Desai et al.[17] concluded that the use of an intraoperative caliper together with adequate preoperative planning were reliable elements in restoring lower limb length discrepancy.

Regarding the evaluation of femoral offset, in both groups, the postoperative offset increased significantly with respect to the preoperative offset by more than 5 mm, but it was not significant when comparing both groups with each other. An inadequate femoral offset reduces soft tissue tension and increases the risk of dislocation; therefore, it is prudent to ensure good abductor apparatus tension.

Kurtz et al.[18] reported a good correlation for limb length, but no difference in offset correction. On the other hand, Chen et al.[19] also achieved an increase in femoral offset with the use of an intraoperative caliper, but without statistical significance with respect to the control group.

This study has several limitations, including its retrospective design and outcome variables that simply collected images and basic patient information without quantifying structural limb length or functional score. Finally, the measurement method may not be accurate in all cases and may generate a measurement bias depending on the quality of the radiograph and the observer.

CONCLUSIONS

This caliper is a simple and reliable method that helps the surgeon to be more accurate in correcting limb length discrepancy and restoring femoral offset in THA. While it does not ensure correction of the exact length discrepancy to 0 mm, it allows us to work within a more reliable and safe range.

Conflict of interest: The authors declare no conflicts of interest.

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