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DETERMINING THE THREE-DIMENSIONAL POSITION OF THE ACETABULAR CUP IN TOTAL HIP ARTHROPLASTY PATIENTS

Determinação do posicionamento tridimensional da cúpula acetabular em pacientes de artroplastia total do quadril

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ABSTRACT

The total hip arthroplasty (THA) stands as one of the best well succeded orthopedic procedures. Despite of that, hip surgery domain still faces challenges on a regular basis. The positioning of THA components related to femur and pelvis is important for the surgery prognostic. Assessing both acetabular incline and anteversion angles during surgical programming will benefit THA procedure. **Objectives**: To evaluate the positioning of acetabular angles in ATQ, measuring its inclination and anteversion. To compare the results with previous studies of literature. **Methods**: By Shapiro Wilk and Bartlett tests were found normality and homogeneity of the variances. The t test was used to compare the findings with values found in literature. Thirty six male subjects who underwent THA were assessed through pelvis radiographies (AP), where the acetabular incline and anteversion angles have been trigonometric calculated. **Results**: 36 male subjects THA, being 61% of those on the left side of the body. The averages were, age 66.96 years (±12.24), acetabular cup incline 44.69º (± 4.65), acetabular anteversion angle 20.12º (±7.01). There were no statistically significant differences when compared to the reference values from literature. **Conclusion**: further studies and technologies must be adopted due to minimize the effects of any subjectivity in the acetabular component positioning, mainly when related to the acetabular anteversion.

Keywords: Biomechanics; orthopedics; hip.

INTRODUCTION

The total hip arthroplasty (THA) stands as one of the best succeeded orthopedic procedures. Despite of that, hip surgery domain still faces challenges on a regular basis.

The THA events are currently increasing in number due to a better human being life expectancy and orthopedic materials updating. Hip replacement surgeries have been more and more indicated to younger patients. Although the great technical and orthopedic materials evolution, there are still countless controversies surrounding implants reliability and performance.

There are excellent THA outcomes for the elderly patients, but not as good as observed in younger ones[1,2,3]. THA is an intervention that causes significant improvements in functional status and in the individual's quality of life (QOL), especially in cases of severe degenerative arthritis.

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The QOL related to health was defined by the World Health Organization (WHO) as a multidimensional model embracing physical, social, environmental and emotional well being. It is highly correlated to subjects' autonomy and their ability to perform daily life activities[4].

It is considered a hard task to obtain more reliable results in this kind of surgical procedure. THA outcomes were assessed only over morbidity rates, mortality, implants tearing and surgical complications. The modern approach to the outcomes of the joint replacement orthopedic surgeries is no longer based only on implant success or failure. The focus is directed to the patient's satisfaction and QOL level[5]. Thus, assessing those rates has clearly become necessary for better understanding the effects of such procedure designed at last for improving one´s QOL[6].

At first, THA pre surgical planning was not well comprehended and utilized, once the prosthesis designs and sizes were too limited[7,8].

Nowadays, the wide range of designs and the variety of the components sizes have increased considerably and changed THA into a more complex procedure. Pre surgical planning allows both an adequate choosing of the components sizes and designs as well as the limbs equalization and surgery time reducing[8].

However, it has been demonstrated the importance of the pre surgical radiograph study due to provide a better choosing of the correct sizes of the prosthesis components, besides emphasizing the importance of restoring the normal hip anatomy by the positioning of those components matching physiological angles. Finding that match addresses a strict relation to arthroplasty stability[7,9,10].

The THA components positioning related to femur and pelvis are important to the surgery prognostic[7]. The acetabular component incline and anteversion angels were defined by Murray et al. (1993)[11] related to three different perspectives: radiographic, surgical, and anatomic. The literature brings several studies pointing how important is to match proper incline and anteversion, as much as their accurate assessment[11,12].

A variety of mathematic, trigonometric and fluoroscopic methods were described to determine the acetabular component positioning on the conventional recommendations[11]. It has been proposed that the ideal radiographic image would find an acetabular anteversion of 15º (10º standard deviation) and a 40º abduction (10º standard deviation) due to avoid impact and luxation[13].

Luxation is a frequent complication following THA, reported on a range frequency from 0.1% to 9%. The main risk factor related to failure is the incorrect positioning of the acetabular component. That neither respects the physiological position nor restores the proper hip biomechanics[12,14,15].

A few studies assessed the acetabular cup position immediately after THA surgery[16], measuring both acetabular incline (abduction)

and anteversion angles. The acetabular component position is assessed accordingly Murray´s technique[11].

That study assessed such positioning on the post-surgery period, limiting the surgeon in case of an incorrect acetabular positioning[16].

The acetabular bowl must present an anteversion, but there is no consensus on the literature concerning the exact angle. A bad positioning of this component, specially its retroversion, may become a significant instability cause. The anteversion or retroversion acetabular angle may not always be assessed through a conventional radiograph[17], mainly due to a lack of studies and instrumental development addressed to solve this problem.

The acetabular incline and anteversion angles assessment during surgical programming will benefit THA procedure, once the surgeon will be able to perform his work in a more effective and safer manner. The biomechanical functional restoring is crucial for both the patient and the success of the surgery.

OBJECTIVES

This research purposes to assess the THA acetabular positioning angles, measuring its incline and anteversion, and compare the outcomes with previous studies in the literature.

METHODS

Accordingly Lakatos et al., (1996)[18], the present study consists in a exploratory field research which purposes to demonstrate the viability of certain technique or program, as well as a solution, potential and feasible, for peculiar practical situations.

The sample size has been calculated over Levine equation (1987)[19] in a 95% confidence interval and 10% maximal estimative error, resulting in 68 subjects. All of the subjects were ambulatory patients at the Hospital São Vicente de Paulo (HSVP) in Jundiaí City (São Paulo State, Brazil). Partial outcomes have been reported, from 36 of 68 sample subjects in this study, all of them presenting for post surgical evaluation in September and October.

The patients' radiographic assessments were performed at the HSVP ambulatory hip specialty laboratory. Those patients find themselves already in late post surgical period, meaning they underwent ATH over six months.

Digital ante-posterior (AP) pelvis digital radiographs were taken for both injured and counter lateral hip assessment. This AP pelvis radiograph is performed with the subject laying on decubitus back-horizontal and lower limbs internal rotation (around 15º). The center of the radiograph is placed nearly 2 cm above the pubic symphysis.

The radiographs were exported to Corel Draw software, where the incline angles were measured through a reference line drawn at the ischium bones base. A second line has been drawn

passing the acetabular cup upper board and lower board. Those lines crossing indicate the acetabular incline angle.

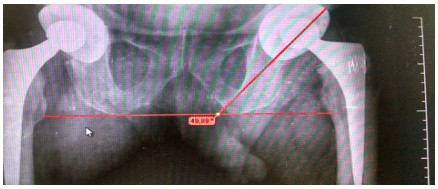


Figure 1: acetabular incline.

Two lines were drawn. The first from the bottom of the acetabular cup to its upper board posterior extremity (TL), and a second one between the anterior board extremity and the acetabular cup posterior board (S).

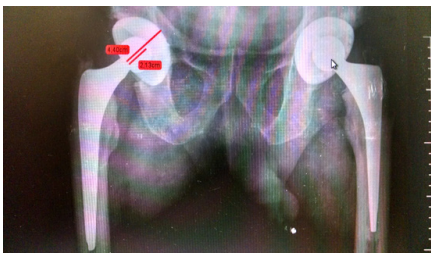


Figure 2: Assessing TL and S

Through (S/TL) rate, obtained the rotation value on its own axis. The acetabular anteversion angle (α) was been obtained over the equation,

$$\text{Arc sin } \alpha = (S/TL) * (180)/(Pi)$$

The calculations were made on Origin Pro 9.0 for determining anteversion angle under a statistical treatment with $P<0,05$ significance level. Shapiro Wilk´s test was used to verify the data normality, and Bartlett´s test checked the variances homogeinity.

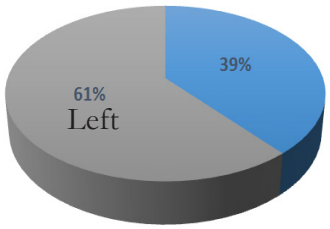
Student´s t test compared the subjects´ averages to previous studies references.

This project has been approved by UNIMEP Ethics Committee (Universidade Metodista de Piracicaba), protocol #59/2015, accordingly National Health Council normative #466/2012, and authorized by HSVP Medical Ethics Council. All of the patients were advised about the study and signed down a free will and clarified consent term.

RESULTS

An amount of 36 ATH was assessed, all male subjects, and 61% had ATH on their left body side. Average age was 66.96 (±12.24) years.

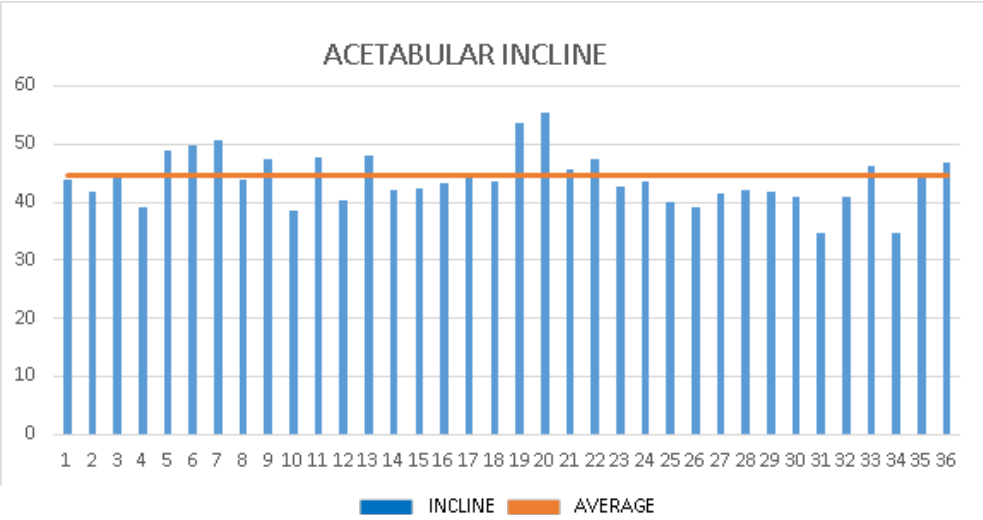
Graphic 1 – Injured side



There is an evidence of average 44.69º (±4.65) subjects' acetabular cup incline (Graph 2).

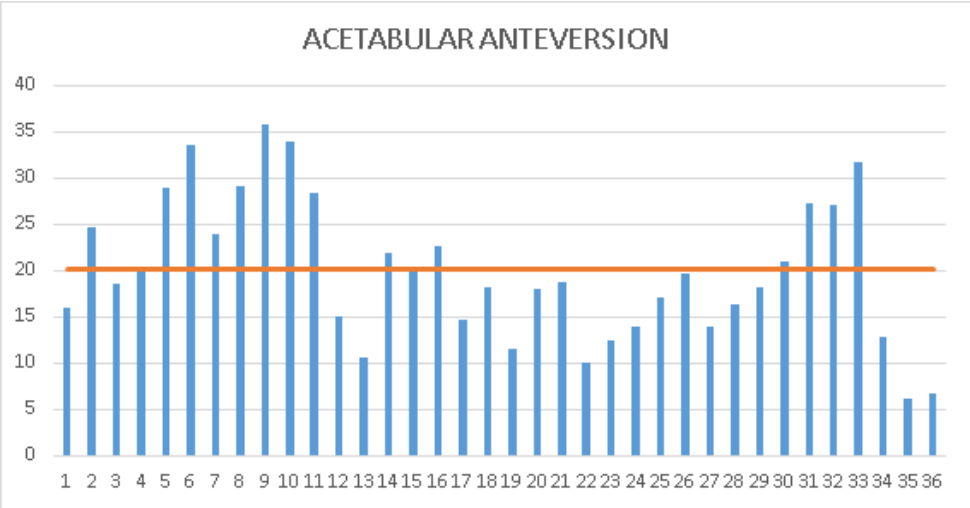
The subjects did not complain of any pain related or not to their range of motion.

All the patients reported either being satisfied to the surgical procedure and an improvement of QOL in daily life activities.



Graphic 2 – Subjects' acetabular incline angle.

The acetabular anteversion angle averaged 20.12º (±7.01)



It has been run a two-tailed t test to assess the difference between groups averages, respectively outcomes t=5.194 e t=3.876 for incline and acetabular anteversion. No statistical significant differences exist for both variables in comparison to a referential value.

The effect size has been calculated, and there was evidence of a small effect, probably due to the high values for standard deviations found in the referential study. The power test equals 0.80 to minimize the chances of an error type II to occur (accepting the null hypothesis as fake).

There was no evidence of THA luxation or instability in the studied sample. The subjects did not complain of any pain related or not to

their range of motion. All the patients reported either being satisfied to the surgical procedure and an improvement of QOL in daily life activities.

DISCUSSION

Radiograph is the best method for both diagnosis and follow-up after THA. It is a low cost assessment and it is possible to be done in any hospital. Meanwhile acetabular incline may be assessed over conventional radiographs, the anteversion calculation still bring some problems. There is a need of more and better studies for the accurate evaluation of the anteversion angle.

The acetabular cup safe range of variation consists in 15° (±10) anteversion and 40° (±10) abduction. However, those numbers are based upon nine luxation cases only[13]. Focusing to prevent impact and luxation, those authors determined the safe range of variation for the cup position between 30° to 50° for abduction and 20° to 40° of horizontal flexing[20]. It has been considered a bad cup positioning any anteversion smaller than 15° or bigger than 30°, and an abduction angle wider than 55º. In order to reach veritable anteversion values, the authors added 5º to the angle assessed on the pelvis radiograph in AP[21].

A study radiographically graduated the acetabular component anteversion exceeding 15º. It was assigned as too much vertical when the abduction angle was bigger than 50º[22].

Another study demonstrated there was no safe variation for the acetabular component positioning, and that a 15º anteversion along with a 45o incline present a smaller luxation risk when the anterior-lateral access was used[23].

Paterno et al., (1997)[24] were not able to establish an association between the anteversion or incline angle of the acetabular component and the luxation risk. They concluded the importance of the incline angle as a risk factor for luxation may have been exaggerated in previous studies. This study demonstrated the acetabular anteversion and incline angle assessment is highly precise, easy to be calculated and greatly reliable when both the ampoule of the equipment is correctly centered over the hip and the trigonometric formula is used. According literature, the incline angle varies from 33° to 50°, and anteversion angle from 15° to 30°[24].

This study demonstrated the incline angle averaged 44.69º, and anteversion 20,12º. Thus, as the outcomes demonstrate, there was no significant incline angle variation. However, related to anteversion angle, there were odds to occur variation among the evaluated subjects.

CONCLUSION

This study revealed the acetabular incline angle presented variations in the standard deviation range earlier reported in previous studies over the same theme.

The acetabular anteversion angle has a heterogeneous values distribution, demonstrating that its positioning is still surgeon subjectivity

highly dependent.

Further studies and technologies must be addressed due to minimize the effects of such subjectivity surrounding the acetabular component positioning, mainly when related to acetabular anteversion.

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