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RESEARCH REPORT

RADIOGRAPHIC EVALUATION OF EARLY OUTCOME AFTER TWO TYPES OF CEMENTLESS HIP ARTHROPLASTY

OCENA RADIOLOGICZNA WCZESNYCH WYNIKÓW DWÓCH RODZAJÓW BEZCEMENTOWEJ ALLOPLASTYKI STAWU BIODROWEGO

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ABSTRACT

Introduction

Total Hip Arthroplasty is one of the most common orthopaedic procedures. Its outcome is assessed by radiographic evaluation. Two principal radiographic parameters are cup inclination and stem position angle.

Aim

The study aimed to compare radiological outcomes of two total hip arthroplasty techniques: Alloclassic Zweymüller versus Corail Pinnacle endoprostheses.

Material and methods

Medical histories of 345 patients who had a hip replacement between 2007 and 2017 were reviewed. Patients with primary total hip arthroplasty with both of mentioned systems were included in the research. Seven observers individually evaluated the radiological images of the 67 endoprostheses (39 Alloclassic Zweymüller and 26 Corail Pinnacle). The cup inclination and the stem position angle were measured using MB-Ruler programme.

Results

There was no statistical difference ($p > 0.338$) in cup inclination angle between Alloclassic Zweymüller and Pinnacle cups, with the angle ranging from 31.01˚ to 58.80˚ (45.20˚ on average) and from 30.61˚ to 59.1˚ (43.60˚ on average), respectively. Femoral stem position did not differ between both types of endoprosthesis ($p > 0.932$), ranging from –1.05˚ to 7.87˚ (3.09˚ on average) for Alloclassic Zweymüller and 0.35˚ to 7.79˚ (3.06˚ on average) for Corail Pinnacle stem. ICC (Intraclass Coefficient Correlation) was estimated and their 95% confident intervals were calculated for cup inclination and stem position showing good reliability of cup inclination measurements.

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Conclusions
Both types of endoprostheses presented similar radiological outcomes. Cup inclination can be used by non-experienced medical staff to reliably assess the postoperative radiograms.

Keywords: cementless hip replacement, radiological outcomes, imaging.

STRESZCZENIE

Wstęp
Całkowita endoprotezoplastyka stawu biodrowego to jeden z najczęściej wykonywanych zabiegów ortopedycznych. Jej wynik ocenia się na podstawie oceny radiograficznej. Dwa główne parametry radiograficzne to nachylenie panewki i kąt ustawienia trzpienia.

Cel
Badanie miało na celu porównanie wczesnych wyników radiologicznych po całkowitej alloplastyce stawu biodrowego z użyciem dwóch typów endoprotez: Alloclassic Zweymüller oraz Corail Pinnacle.

Materiał i metody
Przeanalizowano historię medyczną 345 pacjentów, u których wykonano całkowitą alloplastykę stawu biodrowego w latach 2007–2017. Do badania włączono pacjentów z pierwotną całkowitą alloplastyką stawu biodrowego z użyciem jednego z wymienionych systemów. Siedmiu obserwatorów indywidualnie oceniało radiogramy 67 endoprotez (39 Alloclassic Zweymüller i 26 Corail Pinnacle). Nachylenie panewki i kąt ustawienia trzpienia mierzono za pomocą programu MB-Ruler.

Wyniki
Nie było statystycznej różnicy ($p > 0,338$) w kątach nachylenia panewki pomiędzy endoprotezami Alloclassic Zweymüller i Corail Pinnacle, przy kątach odpowiednio w zakresie od 31,01˚ do 58,80˚ (średnia 45,20˚) i od 30,61˚ do 59,1˚ (średnia 43,60˚). Kąt ustawienia trzpienia nie różnił się między dwoma rodzajami endoprotez ($p>0,932$), z zakresem od −1,05 do 7,87˚ (średnia 3,09˚) dla Alloclassic Zweymüller oraz 0,35˚ do 7,79˚ (średnia 3,06˚) dla trzpienia Corail Pinnacle. Obliczenia współczynnika korelacji wewnątrzklasowej (ICC) dla pomiarów kąta nachylenia panewki i kąta ustawienia trzpienia, wykazały dobrą wiarygodność pomiarów kąta nachylenia panewki.

Wnioski
Pomiary kąta nachylenia panewki wykazały dobrą wiarygodność w ocenie radiologicznej po całkowitej alloplastyce stawu biodrowego. Zarówno endoprotezoplastyka stawu biodrowego przy pomocy protez Alloclassic Zweymüller, jak i Corail Pinnacle wykazała podobne wczesne pooperacyjne wyniki radiologiczne.

Słowa kluczowe: bezcementowa endoprotezoplastyka stawu biodrowego, wyniki radiologiczne, obrazowanie.

Introduction
Total Hip Arthroplasty (THA) is one of the most common orthopaedic procedure of our time. THA relieves pain and restores function, improving the quality of life. In Poland, 59 306

hip replacement surgeries were performed in 2019, and 54 460 of them were primary THAs. 84% of surgeries were performed with cementless types of endoprosthesis. Most frequently performed due to hip pain. Coxarthrosis is one of the reasons of THA. It has excellent clinical results. However, these results can vary depending upon the implant, the surgical technique, the type of fixation, the biomaterials, the patient's age and others (Beswick *et al.* 2012). Prosthesis fixation is assessed during surgery and afterwards, radiographically. In radiogram, leg length due to the prosthetic position is compared with the opposite femur, vertical and horizontal centers of rotation, cup inclination, acetabular and femoral neck anteversion and varus or valgus stem position are assessed (McCollum and Gray 1990). The cup inclination and stem position are measured on the anteroposterior pelvis radiograph as the angle between the cup reference line to the horizontal pelvic reference line. The cup inclination should measure from 30˚ to 50˚. Stem position is measured as the angle between stem axis and femoral axis. The neutral position is optimal (Vanrusselt *et al.* 2015).

Aim

In this paper, we aimed to study two principal radiographic parameters: cup inclination (CI) and stem position (SP) after THA in two groups of patients treated with two different endoprosthesis systems. We have gathered data from several observers to determine whether those parameters are reliable to use.

Material and methods

This study was carried out in the orthopaedic department in Poland, experienced in joint replacements. We retrospectively reviewed 345 patients after THA treated in the department. We have included patients after THA using Alloclassic Zweymüller (AZ) or Corail Pinnacle (CP) endoprosthesis systems performed in the department between 2007 and 2017. In our analysis, we included 67 consecutive patients (Table 1) after Total Hip Arthroplasty based on three inclusion criteria. The inclusion criteria were:

1. primary Total Hip Arthroplasty,
2. Alloclassic Zweymüller or Corail Pinnacle system used,
3. availability of postoperative full pelvic AP X-ray scan with both Koehler's teardrops visible.

Table 1 Characteristics of patients included in the study.

	Corail Pinnacle	**Alloclassic Zweymüller**	**Total**
N	28 (41.8%)	39 (58.2%)	67
Male	13 (56.5%)	10 (43.5%)	23 (34.3% of total *n*)
Female	15 (34.1%)	29 (65.9%)	44 (65.7% of total *n*)
Side	Left – 15; Right – 13	Left – 11; Right – 28	Left – 26; Right – 41
Age	60.43 (SD = 11.14)	71.13 (SD = 4.82)	66.66 (SD = 9.62)

We have compared two different cementless endoprosthesis systems, Corail Pinnacle (CP) and Alloclassic Zweymüller (AZ). Corail system has neck geometry designed for a broad range of motion, high offset point to treat increased femoral offset patients, coxa vara stem option for varus neck angled patients and extensive hydroxyapatite coating. As for Alloclassic Zweymüller, a tapered stem geometry and grit-blasted surface provide proven initial fixation, and rectangular cross-section gives excellent rotational stability.

Among those 67 patients, 39 were treated with Alloclassic Zweymüller endoprosthesis (58.2%) and 28 with Corail Pinnacle endoprosthesis (41.8%). The 23 male and 44 female patients (sex ratio 1 : 1.91) were included in the study.

Seven observers measured radiological parameters of 67 endoprostheses (41 right and 26 left). Each researcher received all of the radiological images to examine and used a separate spreadsheet for their outcomes. MB Ruler programme was used to measure

the cup inclination angle and stem position of the endoprosthesis.

The inclination angle was measured between a line drawn through the superior, and inferior edge of the cup, and the horizontal line drawn through lower ends of both Kohler's teardrops (Figure 1). The stem position angle was measured between the line drawn in the axis of the stem of the endoprosthesis and line drawn in the axis of the proximal part of the femur (Figure 2). The spreadsheets were merged and used in statistical analysis using STATISTICA software with $p < 0.05$ considered as significant.

endoprosthesis was significantly younger (60.43 vs 71.13, Welch test, $p < 0.01$).

The distribution of cup inclination angle in both AZ and CP groups was normal (Kolmogorov-Smirnov test, $p > 0.20$). There was no statistical difference (independent samples t-test, $p > 0.338$) in CI angle between AZ and CP cups, with the angle ranging from 31,01˚ to 58,80˚ (average 45.20˚) and from 30.61˚ to 59.1˚ (average 43.60˚) respectively (Figure 4 4). In the AZ group, 5 of 39 (12.82%) cup inclination angles were above 50˚. In the PC group, 4 of 28 (14.29%) cup inclination angles were above 50˚.

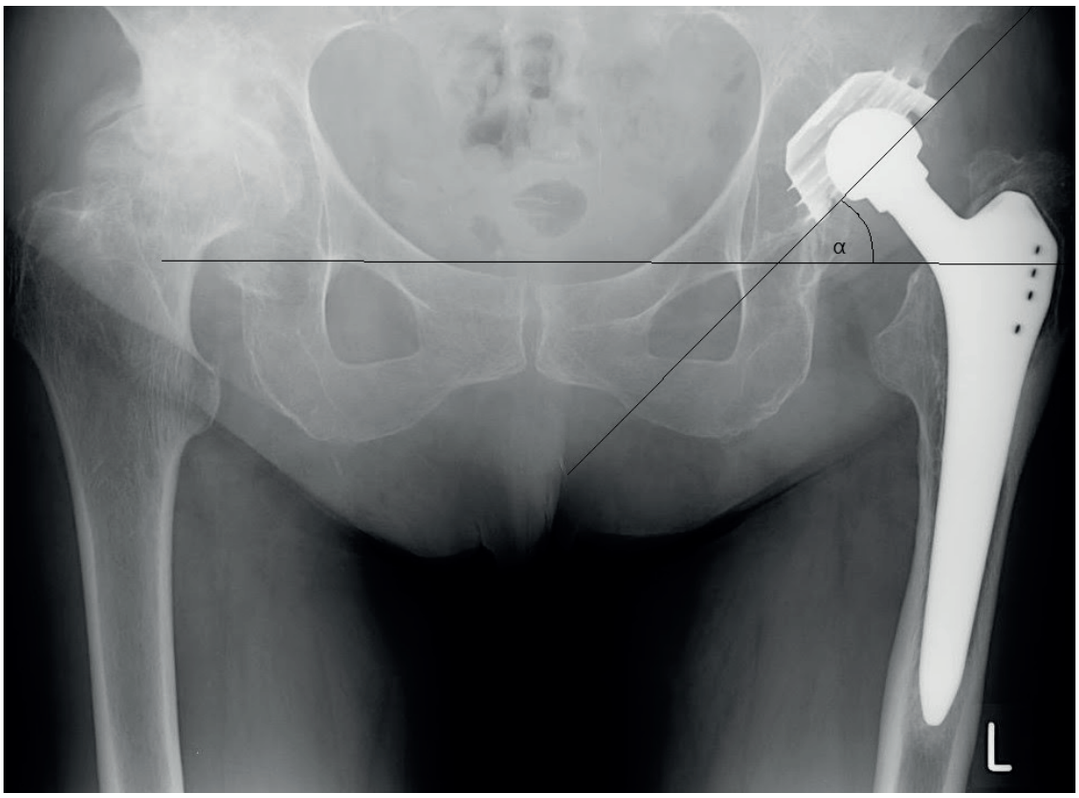

Figure 1. Cup inclination angle measurement method – First, horizontal line is drawn through lower ends of both Kohler's teardrops. Then, second line is drawn through the superior and inferior edge of the cup. Angle between those lines (marked as "α" on the figure above) makes cup inclination angle.

Results

Analysis of gathered data showed that men included in our data required hip replacement at a younger age than women (63.39 vs 68.36, $p = 0.04$, independent samples t-test). There was also a statistically significant difference in age between AZ and PC patients (Figure 3). Patients whose hips was replaced with CP

The distribution of the femoral stem position angle in AZ and CP groups was normal (Kolmogorov-Smirnov test, $p > 0.20$). SP angle did not differ between both types of endoprosthesis (independent t-test, $p > 0.932$), ranging from −1.05˚ to 7.87˚ (average 3.09˚) for AZ and 0.35˚ to 7.79˚ (average 3.06˚) for CP stems (Figure 5). In AZ group, 3 of 39 (7.79%)

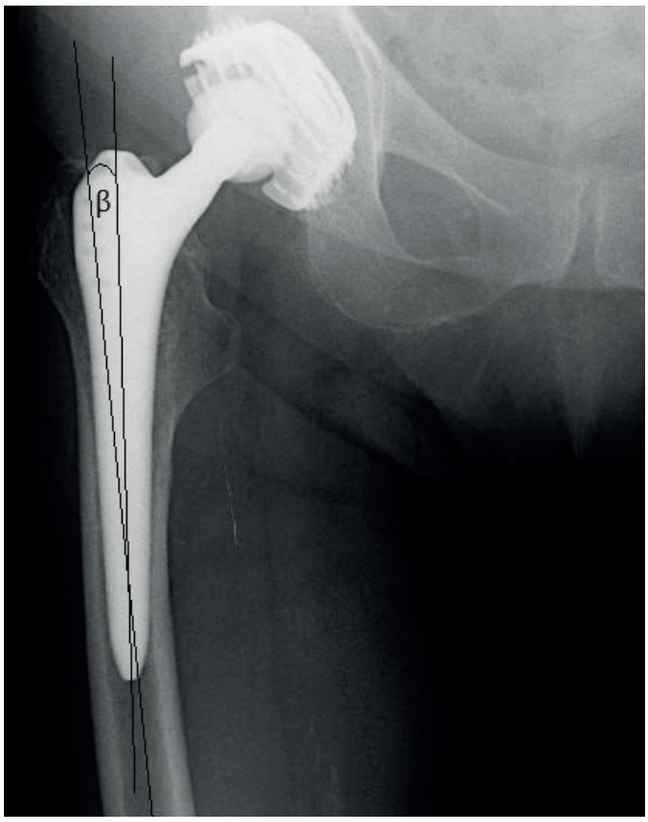

Figure 2. Stem position angle measurement method. First line is drawn in the axis of the endoprosthesis stem. Second line is drawn in the axis of proximal part of the femur. Angle between those lines (marked as "β" on the figure above) makes stem position angle. If the axis of the steam deviates medially to the axis of the proximal femur then the stem position angle is considered varus (as seen on the figure above) – in the opposite situation stem position angle is considered valgus.

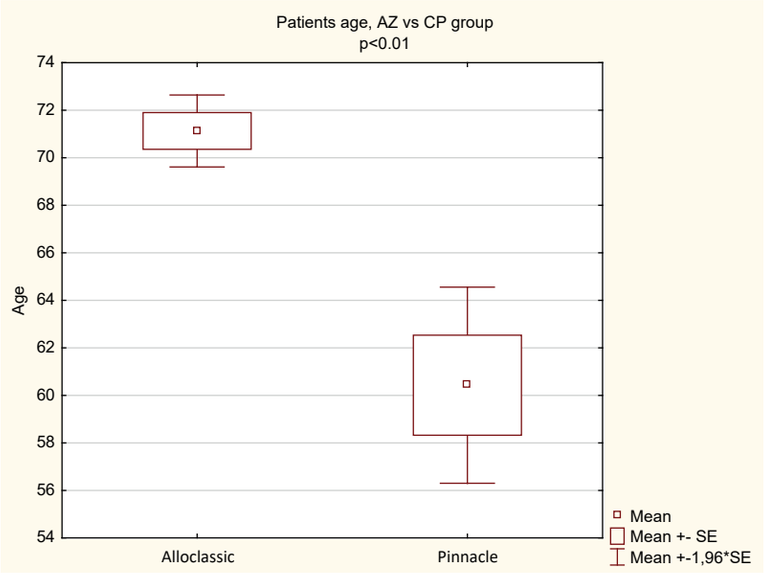

Figure 3. THA patients with AZ arthroplasty were older than patients with CP THA. Difference was statistically significant (Welch test, $p < 0.01$).

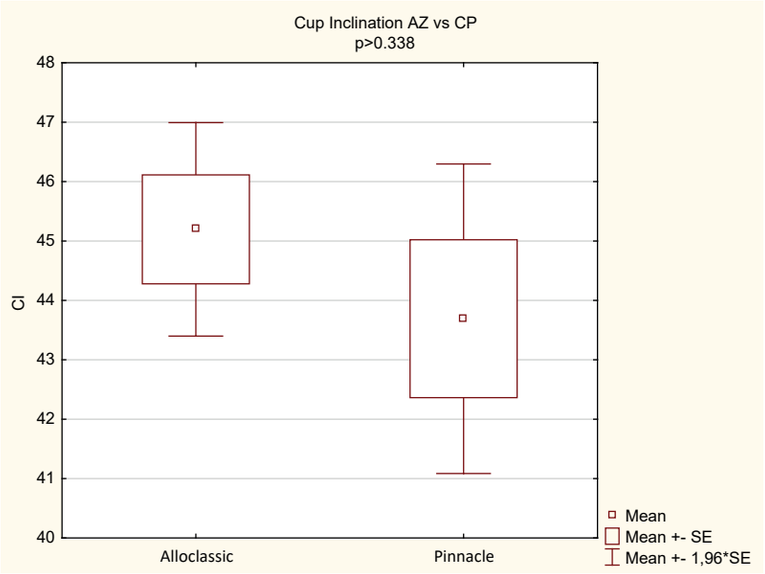

Figure 4. Cup inclination angle after THA with two types of cementless endoprosthesis – Alloclassic Zweymüller and Corail Pinnacle.

stems were in varus position. None of the CP endoprosthesis stems were in varus position.

raters, and tested for absolute agreement. ICC estimates and their 95% confidence intervals

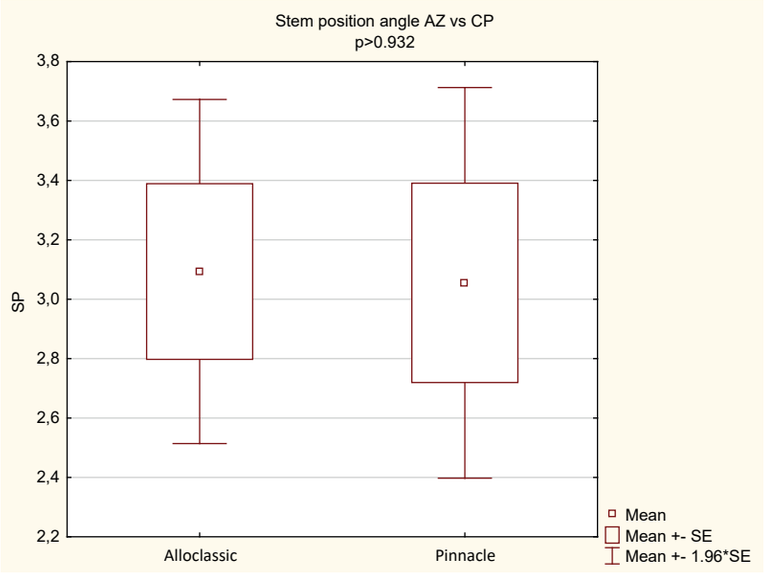

Figure 5. Stem position angle after THA with two types of cementless endoprosthesis – Alloclassic Zweymüller and Corail Pinnacle.

Interrater measurement reliability was assessed through Intraclass Coefficient Correlation (ICC). Seven raters had assessed each radiogram using separate spreadsheets for data collection. Merged spreadsheet with data collected from all of the observers were used in two-way random effects model for multiple

were calculated for cup inclination and stem position (Table 2 and Table 3). Interrater reliability of cup inclination measurements was good between the raters. As it comes to stem position 95% confidence intervals showed reliability from poor to moderate.

Table 2. Cup inclination ICC estimates and 95% confidence intervals. Estimates under 0.5 are considered poor reliability, 0.5–0.75 moderate, 0.75–0.9 good, and > 0.9 excellent reliability.

	Intraclass Correlation Coeficient	**95% Confidence Interval**
Single measures	0.8294	0.7715 to 0.8799
Average measures	0.9715	0.9594 to 0.9809

Table 3. Stem position angle ICC estimates and 95% confidence intervals. Estimates under 0.5 are considered poor reliability, 0.5– 0.75 moderate, 0.75–0.9 good, and > 0.9 excellent reliability.

	Intraclass Correlation Coeficient	**95% Confidence Interval**
Single measures	0.4188	0.3188 to 0.5325
Average measures	0.8345	0.7661 to 0.8886

Discussion

The normal range of cup inclination is between 30˚ and 50˚. CI angle is one of the factors of dislocating a cementless total hip endoprosthesis. Fewer angulation results in a stable hip but limited abduction. Greater angulation substantially increases the risk of hip dislocation. As for stem, the neutral position is optimal. A valgus position is not a significant problem, but a varus position is at risk increased risk of loosening (Munuera and Garcia-Cimbrelo 1992; Jameson *et al.* 2013). In our study group there were 9 endoprosthesis with CI angle higher than 50˚, with similar incidence in both groups, 5 in AZ group (12.82% of cases in this group) and 4 in CP group (14.29% of cases).

Many studies have shown that failure of the femoral stem is associated with varus malpositioning. Some of them states that best position is between 5˚ and 10˚ valgus (Munuera et Garcia-Cimbrelo 1992; Vresilovic *et al.* 1994; Khalily and Lester 2002; Vanrusselt *et al.* 2015). In our study group there were 3 cases of varus position, all of them in AZ group.

The material of patients with AZ Total Hip Arthroplasty gathered by other researchers in Poznań between 1995 and 2004 showed similar outcomes regarding cup inclination angle (mean angle in cases with primary degenerative changes was 42.5 ˚ vs 45,2˚ in our group) and a higher percentage of varus position of the stem (22.6% vs 7.79% in our group) (Pietrzak *et al.* 2010).

AZ system is reliable as it comes to survival time. According to the experience of Pisecky *et al.*, 30-year survival year is achieved by 85.48% patients, and if considered endpoint as removal of stem for aseptic loosening, the survival rate reaches 98.38% at 30 years (Pisecky *et al.* 2018). Cruz-Pardos *et al.* state that probability of survival is 84,1%, and the probability of not having stem loosening is 95.9% both at 20 years after Total Hip Arthroplasty (Cruz-Pardos *et al.* 2017). Weissinger *et al.* presented a rate of reoperation of 6.8% after 20 years after Total Hip Arhtroplasty with AZ cementless total endoprosthesis (Weissinger *et al.* 2010). According to Suckel *et al.*, 95.2% of patients did not need an operative revision after 17 years of observation. The rate of aseptic loosening of the cup was 2%, and the femoral component was 1% (Suckel *et al.* 2009). In Delaunay *et al.* study endpoint was considered as definite aseptic loosening. The survival rate at eight years of observation was 99.3% for the femoral component and 99.1% for the cup (Delaunay *et al.* 1998). Good results of epidemiological studies concerning AZ endoprosthesis may be due to favourable radiological results it provides. In our study group only 3 patients had varus position of the stem, with highest varus angle reaching –1.05˚.

Pennington *et al.* studied total hip arthroplasty in England. They were comparing results of different types (cemented, cementless, hybrid) and brands (including Corail Pinnacle) of endoprosthesis systems. In the 5-year observation CP system presented 2.2% probability of revision and best functional outcome in the cementless group of the endoprosthesis (Pennington *et al.* 2013). Jameson *et*

al. performed a study on 35 386 patients who underwent the procedure of total hip arthroplasty with CP system between 2003 and 2010. In that period, it was the most common type of endoprosthesis in England and Wales. The rate of revision at five years was 2.4% (Jameson *et al.* 2013). AZ and CP systems showed low revision rates in observatory studies, although we have not found studies concerning CP system with more extended observation period.

There was no previous research that compared radiological results of these two popular systems of endoprostheses. However, our results complies with previous observatory studies concerning those prosthesis systems – low rate of varus malpositioning or high cup inclination angle may be the reasons why those endoprostheses provide good clinical results.

Our study also showed that cup inclination angle measurements are reliable in the assessment of radiological outcomes of THA.

Conclusions

Cup inclination angle measurements reveal good reliability in radiological assessment after THA. Both AZ and CP hip arthroplasty demonstrated similar early postoperative radiological outcomes.

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