

# Recovery of the Hip Rotation Center with Tantalum in Revision Arthroplasty\*

## Recuperação do centro de rotação do quadril com tântalo em artroplastias de revisão

Antônio Augusto Guimarães Barros<sup>1</sup>  Victor Atsushi Kasuya Barbosa<sup>1</sup> Lincoln Paiva Costa<sup>1</sup>  
Euler de Carvalho Guedes<sup>1</sup> Carlos César Vassalo<sup>1</sup>

<sup>1</sup> Hospital Madre Teresa, Belo Horizonte, MG, Brazil

Rev Bras Ortop 2019;54:471–476.

**Address for correspondence** Antônio Augusto Guimarães Barros, Alameda do Morro, 85. Nova Lima, MG, 34006-083, Brazil (e-mail: antonioagbarros@gmail.com).

### Abstract

**Objective** The objective of the present study is to evaluate the restoration capacity of the hip anatomic rotation center with the use of acetabular tantalum cups, associated or not with addition wedges.

**Methods** Retrospective analysis of patients undergoing hip arthroplasty revision using tantalum between June 2013 and April 2017. The abduction angle of the acetabular component and the horizontal and vertical distances of the component to the center of anatomical rotation of the hip were evaluated. The measurements were made through baseline radiographs performed in the preoperative period and at the last follow-up visit.

**Results** A sample of 21 patients was obtained, 11 (52%) men and 10 (48%) women, with a mean age of  $62 \pm 13$  years old. The mean abduction angle of the acetabular cup decreased from  $48.76^\circ \pm 13.88^\circ$  in the preoperative period to  $38.52^\circ \pm 10.08^\circ$  in the postoperative period, and this difference was statistically significant ( $p = 0.001$ ). The distances from the center of rotation of the prosthesis relative to the center of anatomical rotation of the hip were also lower after revision surgery with tantalum. The mean horizontal distance of  $12.74 \pm 10.59$  mm was reduced to  $7.11 \pm 4.84$  mm, and the mean vertical distance was reduced from  $14.79 \pm 10.05$  mm to  $4.89 \pm 6.21$  mm, and these reductions were statistically significant ( $p < 0.001$ ).

**Conclusion** Hip arthroplasty revision with tantalum cups, associated or not with addition wedges, significantly recovered the anatomical rotation center of the hip.

### Keywords

- ▶ arthroplasty, replacement, hip
- ▶ acetabulum
- ▶ tantalum

### Resumo

**Objetivos** O objetivo do presente estudo é avaliar a capacidade de restauração do centro de rotação anatômico do quadril com uso de copas acetabulares de tântalo associado ou não a cunhas de adição.

\* Work performed at the Hospital Madre Teresa, Belo Horizonte, MG, Brazil.

 Antônio Augusto Guimarães Barros's ORCID is <https://orcid.org/0000-0003-3701-1937>.

**Métodos** Análise retrospectiva dos pacientes submetidos a revisão de artroplastia do quadril com uso de tântalo entre o período de junho de 2013 e abril de 2017. Foram avaliados o ângulo de abdução do componente acetabular e as distâncias horizontal e vertical do componente ao centro de rotação anatômico do quadril. As medidas foram realizadas através de radiografias da bacia realizadas no pré-operatório e na última visita de seguimento.

**Resultados** Obteve-se uma amostra de 21 pacientes, 11 (52%) homens e 10 (48%) mulheres, com média de idade de  $62 \pm 13$  anos. O ângulo médio de abdução da copa acetabular reduziu de  $48,76^\circ \pm 13,88^\circ$  no pré-operatório para  $38,52^\circ \pm 10,08^\circ$  no pós-operatório, sendo esta diferença estatisticamente significativa ( $p = 0,001$ ). As distâncias do centro de rotação da prótese em relação ao centro de rotação anatômico do quadril também foram menores após a cirurgia de revisão com o tântalo. A distância média horizontal de  $12,74 \pm 10,59$  mm foi reduzida para  $7,11 \pm 4,84$  mm, e a distância média vertical foi reduzida de  $14,79 \pm 10,05$  mm para  $4,89 \pm 6,21$  mm, sendo essas reduções estatisticamente significativas ( $p < 0,001$ ).

#### Palavras-chave

- ▶ artroplastia de quadril
- ▶ acetábulo
- ▶ tântalo

**Conclusão** As revisões de artroplastia do quadril com copas de tântalo, associadas ou não a cunhas de adição, recuperaram de forma significativa o centro de rotação anatômico do quadril.

## Introduction

The number of revision total hip arthroplasty (rTHA) procedures tends to increase in the coming years. In the USA, the number of rTHAs is expected to double between 2005 and 2026.<sup>1</sup> The most common causes for revision are instability (17.3%), aseptic release (16.8%), unspecified mechanical complications (13.4%), and infection (12.8%).<sup>2</sup> In most cases, the acetabular component is replaced, whereas all components are changed in 40.3% of the cases, and the acetabulum alone is replaced in 14.5% of reoperations.<sup>2</sup> The revision of this component with restoration of the anatomical hip rotation center, acetabular bone defects correction, and primary crown stability is a challenge for the orthopedic surgeon.<sup>3</sup> The most commonly described techniques are the use of large or extra-large conventional crowns without cement,<sup>4</sup> cemented cups with or without impacted graft,<sup>5</sup> acetabular reinforcing ring,<sup>6</sup> cup-cage construction,<sup>7</sup> and the use of cups with high-porosity metals (e.g., tantalum) associated or not with addition wedges.<sup>8</sup> Despite the amount of available options, these techniques still present variable results according to the degree of bone lesion, with a failure rate of up to 88.5% of cases after a mean follow-up of 44.6 months.<sup>9</sup>

Even in cases of complex revisions with great bone loss, revision implants coated with high-porosity metal have good results in short- and medium-term follow-ups.<sup>10,11</sup> This material presents theoretical advantages compared with other materials, such as high friction coefficient, modulus of elasticity similar to bone, and a large porosity volume that allows greater osseointegration and better secondary crown fixation.<sup>12,13</sup> However, these are relatively new, expensive materials, and a considerable burden to the health system. The present study aims to evaluate the restoration capacity of the anatomical hip rotation center using acetabular crowns coated with high-

porosity metal, associated or not with addition wedges. Our hypothesis is that rTHAs performed with high-porosity metal are effective in improving the positioning of the hip rotation center when compared with the values recommended by the literature.

## Materials and Methods

Using the arthroplasty database from the hospital of our institution, all of the patients who underwent rTHAs between June 2013 and April 2017 were identified. After approval by the institutional ethics committee, patients submitted to acetabular surgical reconstruction using tantalum-coated components, associated or not to addition wedges (Trabecular Metal, Zimmer, Warsaw, Indiana, USA), were invited to participate in a retrospective analysis. The present study included all patients who underwent THAs using tantalum at the hospital between June 2013 and April 2017, regardless of the reason for the revision, of the degree of bone loss, or of the presence of any comorbidity. Only patients who died or did not perform an adequate segment were excluded.

Defects prior to the surgery were described according to the classification of Paprosky et al,<sup>14</sup> and the radiographic parameters were measured by hip radiographs (anteroposterior [AP] and oblique views) performed during the preoperative periods and at the last follow-up visit. The abduction angle of the acetabular component, in relation to the tear-drop or ischial tuberosity, as well as the horizontal and vertical distances between the component and the anatomical hip rotation center, were measured. From the pelvic height, an isosceles triangle was outlined at 5 mm laterally from the intersection between the Shenton line and the Koehler line, with its sides measuring 20% of the pelvic height. The rotation center is defined as half the length of the hypotenuse.<sup>15</sup>

## Statistical Analysis

Categorical variables were presented as absolute and percentual values, whereas continuous variables were shown as mean and standard deviation (SD). Continuous variables were submitted to a normality evaluation by the Shapiro-Wilk test. The comparison between the pre- and postoperative periods was performed with the two-tailed Student t-test for variables in parametric distribution. For independent samples, the comparison between the two groups was performed through a proper Student t-test after confirming the normal distribution and evaluating variances by the Levene test. The correlation coefficient between pre- and postoperative values for continuous variables was determined by the Spearman test. The correlation power was classified according to the  $r$  value, being strong if  $> 0.70$ , moderate between 0.30 and 0.70, and weak between 0 and 0.30. Data was analyzed with SPSS Statistics for Windows, Version 20.0 (IBM Corp., Armonk, NY, USA), with a 5% significance level.

## Results

Between June 2013 and April 2017, 95 revisions of hip arthroplasty were performed. Of this total, 21 (22%) patients underwent acetabular revision with a tantalum-coated crown, associated or not to addition wedges (Zimmer, Warsaw, IN, USA). A trend for increasing use of this material was observed in our sample (►Fig. 1). The characteristics of the sample are shown in ►Table 1.

The mean abduction angle of the acetabular cup decreased from  $48.76 \pm 13.88^\circ$  at the preoperative period to  $38.52 \pm 10.08^\circ$  at the postoperative period, and this difference was statistically significant ( $p = 0.001$ ). The distances between the rotation center of the prosthesis and the anatomical hip rotation center were also shorter after the revision surgery using an acetabular tantalum component. The mean horizontal distance of  $12.74 \pm 10.59$  mm was reduced to  $7.11 \pm 4.84$  mm, and the mean vertical distance was reduced from  $14.79 \pm 10.05$  mm to  $4.89 \pm 6.21$  mm; both reductions were statistically significant ( $p < 0.001$ ) (►Table 2).

There was a strong direct correlation between the pre- and postoperative values of horizontal distance ( $r = 0.928$ ;  $p < 0.001$ ) and of vertical distance ( $0.792$ ;  $p < 0.001$ ). There-

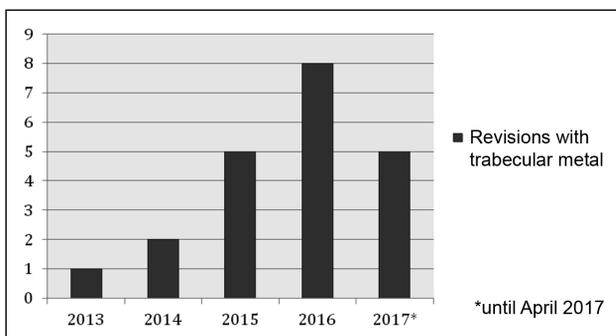


Fig. 1 Trabecular metal use in the last 5 years.

Table 1 Sample characteristics

Patients, $n$	21
Gender, $n$ (%)	
Male	11 (52.4%)
Female	10 (47.6%)
Mean age, years old (standard deviation)	62 ( $\pm 13.2$ )
Revision indication, $n$ (%)	
Aseptic release	15 (71.4%)
Instability	1 (4.8%)
Infection	3 (14.3%)
Pain	2 (9.5%)
Number of previous revisions, $n$ (%)	
0	11 (52.4%)
1	8 (38.1%)
2	2 (9.5%)
Paprosky classification, $n$ (%)	
Type 1	3 (14.3%)
Type 2 <sup>a</sup>	3 (14.3%)
Type 2B	6 (28.6%)
Type 2C	0 (0%)
Type 3 <sup>a</sup>	2 (9.5%)
Type 3B	2 (9.5%)
Pelvic discontinuity	5 (23.8%)

fore, the presence of a greater distance to the anatomical hip rotation center before the revision was also associated to a greater distance after the surgery, indicating that major rotation center deviations present smaller postoperative corrections (►Table 3).

Comparing the postoperative radiographic results between both groups without previous revision (11 patients) and with previous revision (10 patients), no statistically significant difference was observed in the crown abduction angles or in the distances to the anatomical hip rotation center (►Table 4).

## Discussion

The present study showed that the use of tantalum-coated acetabular cups, associated or not with addition wedges, was effective in recovering the anatomical hip rotation center in rTHA surgeries (►Figs. 2a, 2b, 3a and 3b). Thus, the hypothesis of the present study was corroborated.

Correct acetabular positioning is fundamental to the success of total hip arthroplasty (THA), which may influence the load inflicted to the joint and implant wear. Regarding the anatomical hip rotation center, each millimeter of crown lateralization and proximalization is associated with an increase of 0.7% and of 0.1% in the joint load, respectively.<sup>16</sup> There is some consensus in the literature that the acetabular crown should be up to a maximum distance of 5 mm from the anatomical hip rotation center.<sup>17-19</sup> Cup positioning with an abduction angle  $> 45^\circ$

**Table 2** Radiological results of hip mechanics

	Preoperative	Postoperative	<i>p</i> -value
Acetabular cup abduction angle*, mean $\pm$ standard deviation	48.76 $\pm$ 13.88	38.52 $\pm$ 10.08	$p = 0.001^a$
Horizontal distance**, mean $\pm$ standard deviation	12.74 $\pm$ 10.59	7.11 $\pm$ 4.84	$p < 0.001^a$
Vertical distance**, mean $\pm$ standard deviation	14.79 $\pm$ 10.05	4.89 $\pm$ 6.21	$p < 0.001^a$

\*Value in degrees.

\*\*Value in mm.

<sup>a</sup>Two-tailed Student t-test.**Table 3** Correlation between preoperative and postoperative radiological values<sup>a</sup>

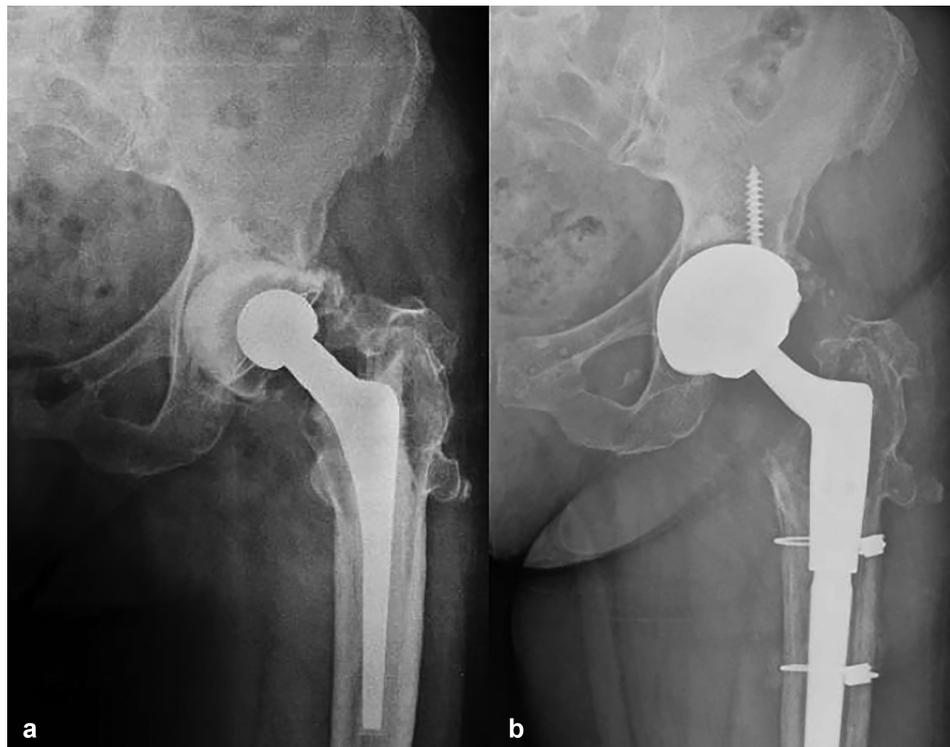
	R value	<i>p</i> -value
Acetabular cup abduction angle	0.525	$p = 0.015$
Horizontal distance	0.928	$p < 0.001$
Vertical distance	0.792	$p < 0.001$

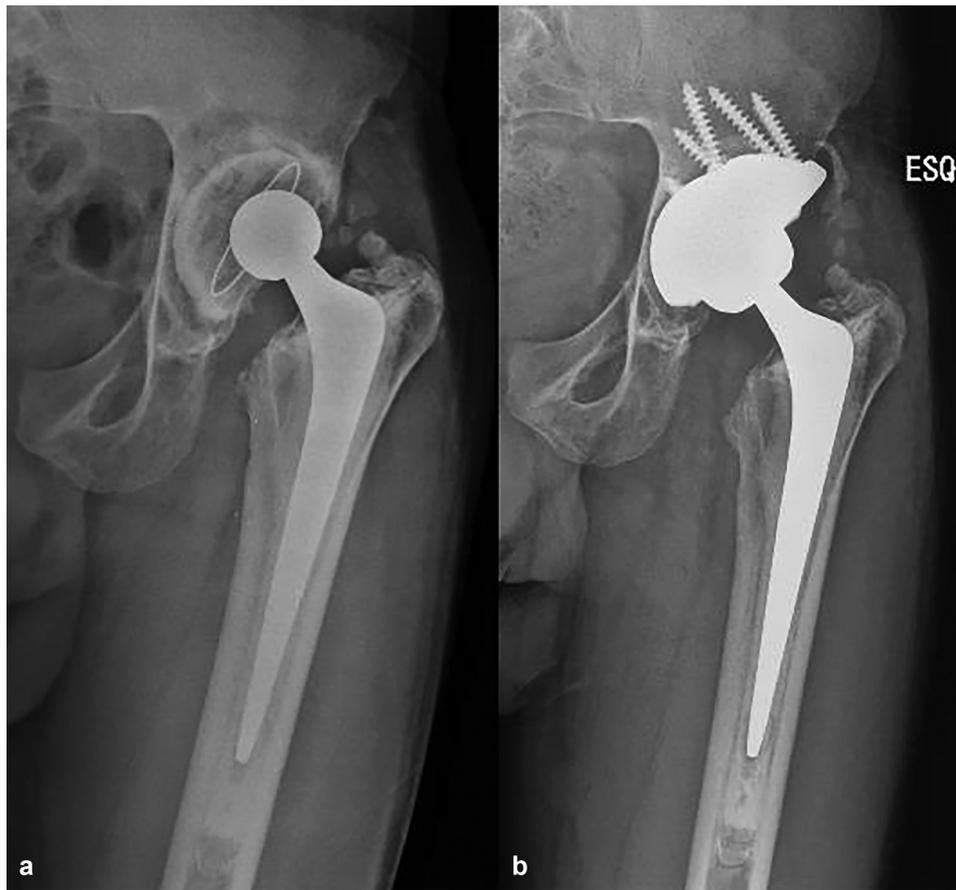
<sup>a</sup>Spearman correlation coefficient.**Table 4** Comparison of postoperative radiological results between the groups with and without previous revisions

	Absence of previous revision	Presence of previous revision	<i>p</i> -value
Acetabular cup abduction angle*, mean $\pm$ standard deviation	36.09 $\pm$ 11.29	41.20 $\pm$ 8.29	$p = 0.256^a$
Horizontal distance**, mean $\pm$ standard deviation	6.36 $\pm$ 3.66	7.94 $\pm$ 5.98	$p = 0.470^a$
Vertical distance**, mean $\pm$ standard deviation	3.65 $\pm$ 6.37	6.24 $\pm$ 6.06	$p = 0.354^a$

\*Value in degrees.

\*\*Value in mm.

<sup>a</sup>Student t-test for independent samples.**Fig. 2** Recovery of the hip rotation center with tantalum cup without addition of wedge. a) Preoperative radiography; b) Postoperative radiography.



**Fig. 3** Recovery of the hip rotation center with tantalum cup and addition of wedge. a) Preoperative radiography; b) Postoperative radiography.

was associated with a 40% increase in the average linear wear of polyethylene.<sup>20</sup> A more horizontal acetabular cup positioning may reduce pelvic osteolysis. Kennedy et al<sup>21</sup> assessed 75 patients submitted to THA who were divided in 2 groups with mean abduction values of 61.9° and 49.7°, respectively; these authors observed pelvic osteolysis rates of 24% and of 13% in higher and lower acetabular inclination groups, respectively, after 4 years of follow-up.

The improvement of the position of the hip rotation center may be beneficial to the functional results,<sup>22</sup> since the center of rotation is very important for muscle function. Asayama et al,<sup>23</sup> when studying 30 patients submitted to THA, found a negative correlation between abductor musculature strength and the proximalization of the hip rotation center. Another study of biomechanical analysis in a lower limb model showed that a 2 cm superior deviation was related to a 44% decrease in abductor strength.<sup>24</sup> The weakness of the abductor hip muscle was one of the most important causes of prosthesis dislocation in a study involving 1,318 patients.<sup>25</sup>

Abolghasemian et al<sup>26</sup> corroborated the results of the improvement of the positioning of the acetabular component rotation center after revision with a high-porosity metal. The position of the rotation center improved in both axes after the revision; the mean distance to the anatomical center prior to the revision was 28.8 mm (- 3 to 79 mm) on the vertical axis, and 13.3 mm (- 21 to 35 mm) on the horizontal axis. At the

postoperative period, the mean distance from the rotation center was 9.9 mm (- 18 to 37 mm) superior, and 5.1 mm (- 25 to 30 mm) lateral to the anatomical center. Jenkins et al<sup>10</sup> also reported recovery of the hip rotation center. The mean horizontal distance to the hip rotation center decreased from 9 mm preoperatively (range: 1 to 45 mm) to 8 mm postoperatively (range: 0 to 27 mm) ( $p = 0.0143$ ), and it was 9 mm (range: 0 to 26 mm) at the last follow-up visit. The mean vertical distance to the hip rotation center decreased from 21 mm preoperatively (range: 0 to 80 mm) to 6 mm postoperatively (range: 0 to 28 mm) ( $p = 0.0001$ ), and it was 4.5 mm (range: 0 to 57 mm) at the last follow-up visit. The mean abduction angle of the acetabular cup was 61° at the preoperative period (range: - 18° to 180°), 45° postoperatively (range: 34° to 60°) ( $p = 0.0001$ ), and 45° (range: 34° to 82°) at the last follow-up visit.

The present study has some limitations. It is a retrospective study with a relatively small sample of 21 patients. The restoration of the rotation center was evaluated only in the coronal plane, not considering anteroposterior deviations; moreover, the acetabular version was not evaluated.

## Conclusion

Tantalum-coated acetabular cups, associated or not with addition wedges, were effective in significantly improving

the positioning of the anatomical hip rotation center in revision surgeries.

#### Conflicts of Interests

The authors have no conflicts of interests to declare.

#### References

- Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *J Bone Joint Surg Am* 2007;89(04):780–785
- Gwam CU, Mistry JB, Mohamed NS, Thomas M, Bigart KC, Mont MA, et al. Current Epidemiology of Revision Total Hip Arthroplasty in the United States: National Inpatient Sample 2009 to 2013. *J Arthroplasty* 2017;32(07):2088–2092
- Paprosky WG, Magnus RE. Principles of bone grafting in revision total hip arthroplasty. Acetabular technique. *Clin Orthop Relat Res* 1994;(298):147–155
- Lachiewicz PF, Soileau ES. Fixation, survival, and dislocation of jumbo acetabular components in revision hip arthroplasty. *J Bone Joint Surg Am* 2013;95(06):543–548
- Schreurs BW, Keurentjes JC, Gardeniers JW, Verdonshot N, Slooff TJ, Veth RP. Acetabular revision with impacted morsellised cancellous bone grafting and a cemented acetabular component: a 20- to 25-year follow-up. *J Bone Joint Surg Br* 2009;91(09):1148–1153
- Mäkinen TJ, Kuzyk P, Safir OA, Backstein D, Gross AE. Role of cages in revision arthroplasty of the acetabulum. *J Bone Joint Surg Am* 2016;98(03):233–242
- Mäkinen TJ, Fichman SG, Watts E, Kuzyk PR, Safir OA, Gross AE. The role of cages in the management of severe acetabular bone defects at revision arthroplasty. *Bone Joint J* 2016;98-B(1, Suppl A):73–77
- Laaksonen I, Lorimer M, Gromov K, Rolfson O, Mäkelä KT, Graves SE, et al. Does the risk of rerevision vary between porous tantalum cups and other cementless designs after revision hip arthroplasty? *Clin Orthop Relat Res* 2017;475(12):3015–3022
- Kosashvili Y, Backstein D, Safir O, Lakstein D, Gross AE. Acetabular revision using an anti-protrusion (ilio-ischial) cage and trabecular metal acetabular component for severe acetabular bone loss associated with pelvic discontinuity. *J Bone Joint Surg Br* 2009;91(07):870–876
- Jenkins DR, Odland AN, Sierra RJ, Hanssen AD, Lewallen DG. Minimum five-year outcomes with porous tantalum acetabular cup and augment construct in complex revision total hip arthroplasty. *J Bone Joint Surg Am* 2017;99(10):e49
- Konan S, Duncan CP, Masri BA, Garbus DS. Porous tantalum uncemented acetabular components in revision total hip arthroplasty: a minimum ten-year clinical, radiological and quality of life outcome study. *Bone Joint J* 2016;98-B(06):767–771
- Bobyn JD, Stackpool GJ, Hacking SA, Tanzer M, Krygier JJ. Characteristics of bone ingrowth and interface mechanics of a new porous tantalum biomaterial. *J Bone Joint Surg Br* 1999;81(05):907–914
- Bobyn JD, Poggie RA, Krygier JJ, Lewallen DG, Hanssen AD, Lewis RJ, et al. Clinical validation of a structural porous tantalum biomaterial for adult reconstruction. *J Bone Joint Surg Am* 2004;86-A(Suppl 2):123–129
- Paprosky WG, Perona PG, Lawrence JM. Acetabular defect classification and surgical reconstruction in revision arthroplasty. A 6-year follow-up evaluation. *J Arthroplasty* 1994;9(01):33–44
- Pagnano W, Hanssen AD, Lewallen DG, Shaughnessy WJ. The effect of superior placement of the acetabular component on the rate of loosening after total hip arthroplasty. *J Bone Joint Surg Am* 1996;78(07):1004–1014
- Bicanic G, Delimar D, Delimar M, Pecina M. Influence of the acetabular cup position on hip load during arthroplasty in hip dysplasia. *Int Orthop* 2009;33(02):397–402
- Liebs TR, Nasser L, Herzberg W, Rütger W, Hassenpflug J. The influence of femoral offset on health-related quality of life after total hip replacement. *Bone Joint J* 2014;96-B(01):36–42
- 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(10):1863–1869
- Jolles BM, Zangger P, Leyvraz PF. Factors predisposing to dislocation after primary total hip arthroplasty: a multivariate analysis. *J Arthroplasty* 2002;17(03):282–288
- Patil S, Bergula A, Chen PC, Colwell CW Jr, D'Lima DD. Polyethylene wear and acetabular component orientation. *J Bone Joint Surg Am* 2003;85-A(04, Suppl 4):56–63
- Kennedy JG, Rogers WB, Soffe KE, Sullivan RJ, Griffen DG, Sheehan LJ. Effect of acetabular component orientation on recurrent dislocation, pelvic osteolysis, polyethylene wear, and component migration. *J Arthroplasty* 1998;13(05):530–534
- Kim DH, Cho SH, Jeong ST, Park HB, Hwang SC, Park JS. Restoration of the center of rotation in revision total hip arthroplasty. *J Arthroplasty* 2010;25(07):1041–1046
- Asayama I, Chamnongkitch S, Simpson KJ, Kinsey TL, Mahoney OM. Reconstructed hip joint position and abductor muscle strength after total hip arthroplasty. *J Arthroplasty* 2005;20(04):414–420
- Delp SL, Maloney W. Effects of hip center location on the moment-generating capacity of the muscles. *J Biomech* 1993;26(4-5):485–499
- García-Rey E, García-Cimbreló E. Abductor biomechanics clinically impact the total hip arthroplasty dislocation rate: a prospective long-term study. *J Arthroplasty* 2016;31(02):484–490
- Abolghasemian M, Tangsataporn S, Sternheim A, Backstein D, Safir O, Gross AE. Combined trabecular metal acetabular shell and augment for acetabular revision with substantial bone loss: a mid-term review. *Bone Joint J* 2013;95-B(02):166–172