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

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

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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 ± 13 years old. The mean abduction angle of the acetabular cup decreased from 48.76° ± 13.88 ° in the preoperative period to 38.52° ± 10.08 ° 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 ± 10.59 mm was reduced to 7.11 ± 4.84 mm, and the mean vertical distance was reduced from 14.79 ± 10.05 mm to 4.89 ± 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.

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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 ± 13 anos. O ângulo médio de abdução da copa acetabular reduziu de 48,76° ± 13,88° no pré-operatório para 38,52° ± 10,08° 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 ± 10,59 mm foi reduzida para 7,11 ± 4,84 mm, e a distância média vertical foi reduzida de 14,79 ± 10,05 mm para 4,89 ± 6,21 mm, sendo essas reduções estatisticamente significativas ($p < 0{,}001$).

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.

Palavras-chave
- artroplastia de quadril
- acetábulo
- tântalo

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.[1] The most common causes for revision are instability (17.3%), aseptic release (16.8%), unspecified mechanical complications (13.4%), and infection (12.8%).[2] 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.[2] 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.[3] The most commonly described techniques are the use of large or extra-large conventional crowns without cement,[4] cemented cups with or without impacted graft,[5] acetabular reinforcing ring,[6] cup-cage construction,[7] and the use of cups with high-porosity metals (e.g., tantalum) associated or not with addition wedges.[8] 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.[9]

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.[10,11] 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.[12,13] 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,[14] 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 teardrop 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.[15]

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 $48.76 \pm 13.88°$ at the preoperative period to $38.52 \pm 10.08°$ 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 ± 10.59 mm was reduced to 7.11 ± 4.84 mm, and the mean vertical distance was reduced from 14.79 ± 10.05 mm to 4.89 ± 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; $p < 0.001$). Therefore, 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**).

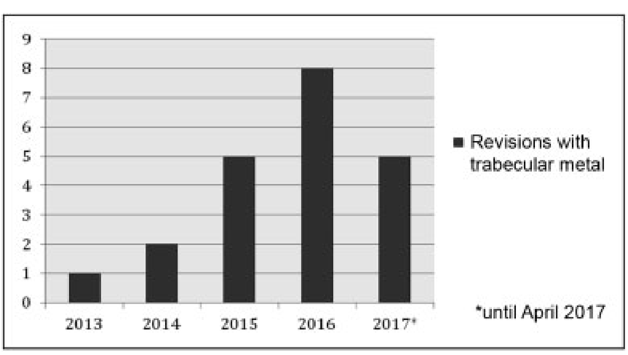

Fig. 1 Trabecular metal use in the last 5 years.

Table 1 Sample characteristics

Patients, *n*	**21**
Gender, *n* (%)	
Male	11 (52.4%)
Female	10 (47.6%)
Mean age, years old (standard deviation)	62 (±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[a]	3 (14.3%)
Type 2B	6 (28.6%)
Type 2C	0 (0%)
Type 3[a]	2 (9.5%)
Type 3B	2 (9.5%)
Pelvic discontinuity	5 (23.8%)

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.[16] 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.[17–19] Cup positioning with an abduction angle $> 45°$

Table 2 Radiological results of hip mechanics

	Preoperative	Postoperative	*p-value*
Acetabular cup abduction angle*, mean ± standard deviation	48.76 ± 13.88	38.52 ± 10.08	$p = 0.001$[a]
Horizontal distance**, mean ± standard deviation	12.74 ± 10.59	7.11 ± 4.84	$p < 0.001$[a]
Vertical distance**, mean ± standard deviation	14.79 ± 10.05	4.89 ± 6.21	$p < 0.001$[a]

*Value in degrees.
**Value in mm.
[a]Two-tailed Student t-test.

Table 3 Correlation between preoperative and postoperative radiological values[a]

	R value	*p-value*
Acetabular cup abduction angle	0.525	p = 0.015
Horizontal distance	0.928	p < 0.001
Vertical distance	0.792	p < 0.001

[a]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	*p-value*
Acetabular cup abduction angle*, mean ± standard deviation	36.09 ± 11.29	41.20 ± 8.29	p = 0.256[a]
Horizontal distance**, mean ± standard deviation	6.36 ± 3.66	7.94 ± 5.98	p = 0.470[a]
Vertical distance**, mean ± standard deviation	3.65 ± 6.37	6.24 ± 6.06	p = 0.354[a]

*Value in degrees.
**Value in mm.
[a]Student t-test for independent samples.

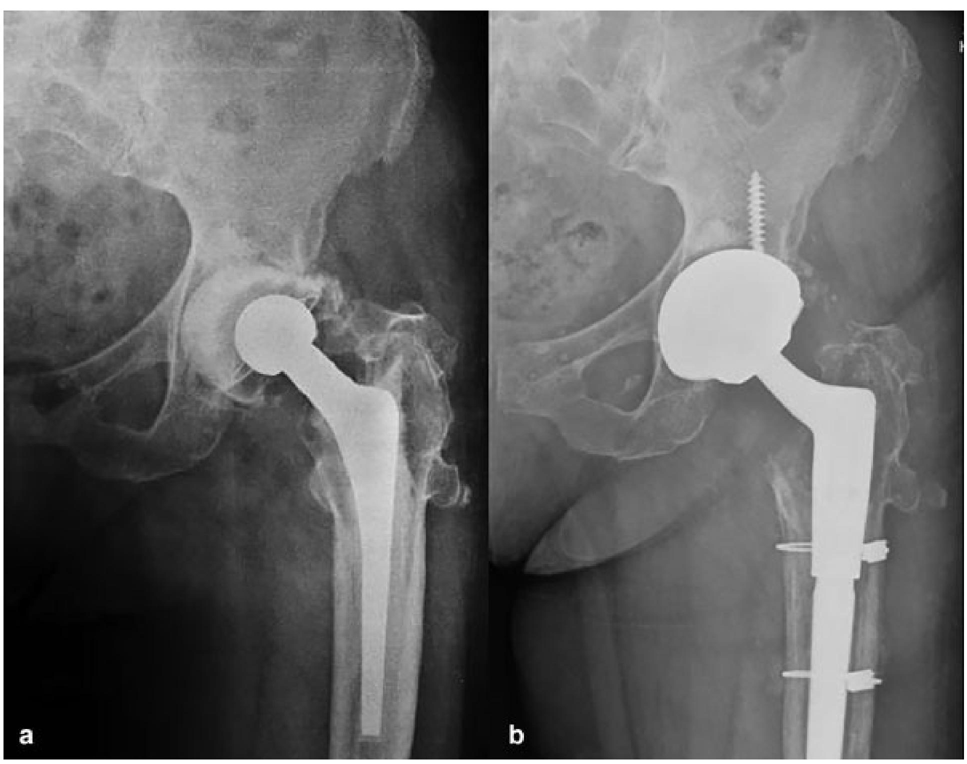

Fig. 2 Recovery of the hip rotation center with tantalum cup without addition of wedge. a) Preoperative radiography; b) Postoperative radiography.

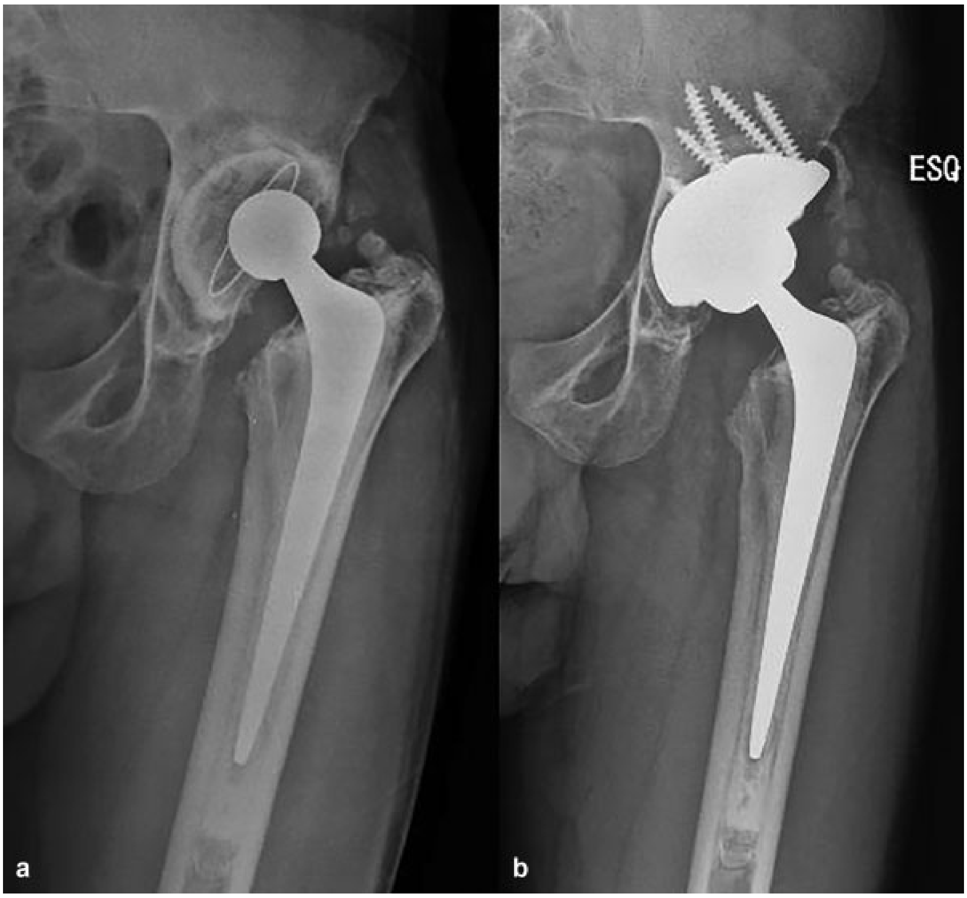

Fig. 3 Recovery of the hip rotation center with tantalum cup and addition of wedge. a) Preoperative radiography; b) Postoperative radiography.

was associated with a 40% increase in the average linear wear of polyethylene.[20] A more horizontal acetabular cup positioning may reduce pelvic osteolysis. Kennedy et al[21] 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,[22] since the center of rotation is very important for muscle function. Asayama et al,[23] 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.[24] The weakness of the abductor hip muscle was one of the most important causes of prosthesis dislocation in a study involving 1,318 patients.[25]

Abolghasemian et al[26] 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[10] 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.

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