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Original Article

Is the size of the acetabular bone lesion a predictive factor for failure in revisions of total hip arthroplasty using an impacted allograft?☆

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ABSTRACT

Objective: The aim of this study was to determine the acetabular bone lesion size (in millimeters) from which impacted bone graft failure starts to occur more frequently, through simple anteroposterior hip radiographs, and whether measurement of the defect on simple radiographs maintains the same pattern in inter and intraobserver assessments.

Methods: Thirty-eight anteroposterior pelvic-view radiographs from patients undergoing revision of an acetabular prosthesis were retrospectively analyzed and assessed. In the vertical plane, the bilacrimal line was measured in millimeters from the farthest point found on the bone edge of the acetabular osteolysis to the top edge of the cementation or of the acetabular implant in uncemented cases. The base was taken to be a line perpendicular to bilacrimal line, with the aim of eliminating any pelvic tilt effects. This measurement was named the vertical size of failure. Radiographs produced four years after the operation were analyzed to investigate any failure of the technique.

Results: The graft failure rate in the study group was 26.3%. The failures occurred in cases with an initial bone defect larger than 11 mm. No cases with measurements smaller than this evolved with failure of the revision. The highest incidence of graft failure occurred in cases described as advanced according to the "Paprosky" classification.

Conclusion: Failure of acetabular revision arthroplasty using an impacted graft did not present any statistically significant correlation with the vertical extent of the lesion on simple anteroposterior radiographs, as a predictor of treatment failure.

☆ Study conducted at the Faculdade de Ciências Médicas da Santa Casa de Misericórdia de São Paulo, Departamento de Ortopedia e Traumatologia, Grupo do Quadril, São Paulo, SP, Brazil.

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O tamanho da lesão óssea acetabular é fator preditivo para a falha nas revisões de artroplastia total do quadril com enxerto impactado?

Palavras-chave:
Artroplastia de quadril
Transplante ósseo
Acetábulo
Aloenxertos

R E S U M O

Objetivo: O presente trabalho buscou, através de uma radiografia simples anteroposterior do quadril, quantificar em milímetros a partir de qual tamanho da lesão óssea acetabular ocorre com maior frequência falha do enxerto ósseo impactado e se a medição do defeito nas radiografias simples mantém o mesmo padrão na avaliação inter e intraobservador.

Métodos: Foram analisadas e aferidas retrospectivamente 38 radiografias de pacientes submetidos à revisão de prótese acetabular na incidência anteroposterior de bacia, mensurando em milímetros, no plano vertical a linha bilacrimal, a medida entre o ponto mais distante encontrado na borda óssea da osteolise acetabular, com a margem superior da cimentação ou implante acetabular nos casos não cimentados. Tomamos como base uma linha perpendicular a linha bilacrimal com o intuito de eliminar efeitos de inclinação pelvic. Essa medida foi denominada Tamanho Vertical da Falha. Radiografias pós-operatórias com quatro anos foram analisadas para averiguar falha da técnica.

Resultados: No grupo estudado observamos 26,3% de falhas do enxerto que ocorreram a partir de 11 mm de tamanho da falha óssea inicial mensurada e que abaixo desse valor nenhum caso evoluiu com falha da revisão. A maior incidência da falha do enxerto ocorreu nos casos avançados segundo a classificação de Paprosky.

Conclusão: A falha na artroplastia de revisão acetabular com enxerto impactado quando relacionado à medida vertical da lesão em radiografia simples anteroposterior do quadril não apresentou significância estatística como fator preditivo de falha do tratamento.

Introduction

The consolidation of contemporary total hip arthroplasty techniques has resulted in an increase in the use of this procedure. Therefore, the need for revision surgery has become a more common problem.[1]

The restoration of the anatomy and biomechanics improves durability and function of the revised hip. The most challenging aspect of acetabular revision is to compensate for acetabular bone loss and create a stable reconstruction, with good long term durability.[2]

Various techniques are described to rebuild extensive acetabular defects, including structural grafts or impacted graft chips, reinforcement rings with cages, placement of the acetabular component in a high hip center, jumbo acetabular cups, bilobed acetabular cups, triflange cups, and trabecular metal acetabular augments.[2]

Although more modern prosthesis revision techniques are available, associated with new implants, this procedure remains a challenge, even for more experienced surgeons.[3]

The loosening of cemented or cementless components in total hip arthroplasty is always accompanied by loss of bone stock. Sloof et al.[4] proposed the use of impacted bone graft in revisions of this component when bone loss was significant.

Acetabular reconstruction with impacted bone graft and a cemented cup is a reliable technique, with a ten-year survival rate of 88% in patients with extensive acetabular defects.[2] Bone loss can be determined by the classification of Paprosky et al.,[5] which provides a simple algorithm to determine bone defect and direct treatment for revision in total hip arthroplasty.

Brown et al.,[6] in a study that used the Paprosky classification, demonstrated an interobserver reliability of 0.61. This indicates a substantial agreement among surgeons. The intraobserver reliability for each of the four surgeons in that study was 0.81, 0.78, 0.76, and 0.75, which indicates substantial agreement.

This study aimed to assess whether acetabular bone loss, measured in a simple anteroposterior radiograph of the pelvis, is a predictive factor for failure in the revision technique with impacted bone graft, and whether the measurement of the defect in plain radiographs maintains the same pattern for inter- and intraobserver assessments.

Material and methods

This study was approved by the Research Ethics Committee, under CAEE No. 07779812.6.0000.5479. Postoperative pelvic radiographs of 38 patients undergoing revision surgery for total hip arthroplasties were assessed; these patients were operated on by three experienced hip surgeons between 1995 and 2008.

The study included X-rays of patients of both genders who underwent acetabular revision with cemented or uncemented prosthesis, with homologous cancellous impacted graft provided by a bone bank. Hip X-rays in anteroposterior view were selected, with a minimum follow-up of 48 months, all standardized according to previously recommended and

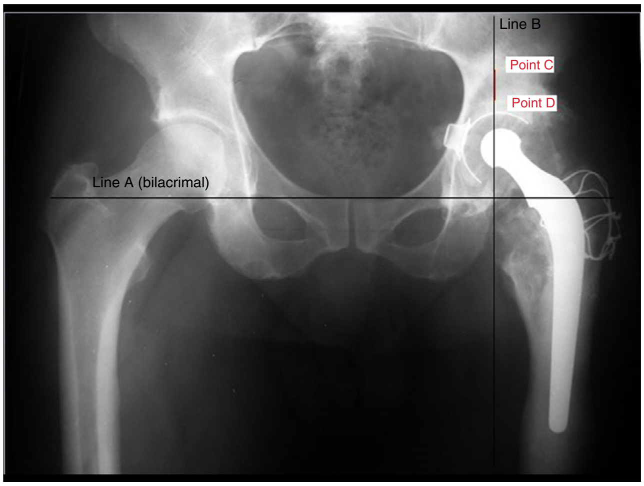

Fig. 1 – Hip X-ray in anteroposterior incidence showing measurement of the size of bone defect in millimeters in the vertical plane; this measurement corresponds to the greatest distance between the edge of the acetabular lesion (point C) and the acetabular roof in its anatomical position (point D).

published standards by the hip group: patient in the supine or standing position; ray incidence on the median line, immediately above the pubic symphysis, feet internally rotated at 15–20° when possible (for correction of the neck anteversion angle), so that the greater trochanter did not overlap the femoral neck; and the coccyx should be visualized and aligned with the pubic symphysis, with a cranial distance of 2.5 cm in females and 1.5 cm in males. The obturator foramen should be symmetrical.[7] All radiographs studied were analogical, with magnification of 100%. Cases of septic loosening were excluded.

After the selection of X-rays, the acetabular component of the prosthesis was analyzed and the bone loss prior to the review was classified using the Paprosky method. The bone defect was measured in millimeters. The measurement was made by three orthopedists: each made two assessments, with an interval of one week.

Bone loss was measured as follows: in the hip radiography in anteroposterior incidence, the bilacrimal line was drawn (line A). Next, line B was drawn perpendicular to line A, in a path that included most of the acetabular failure to be studied, and two points were set (C and D). Point C corresponded to the upper edge of the acetabular failure, and point D, to the top edge of the acetabular cement or of the acetabular cup in cementless cases. The distance between points C and D was measured in millimeters and termed vertical size of the acetabular failure (Fig. 1).

Subsequently, radiographs were analyzed after a mean of 48 months follow-up and it was determined whether or not loosening of the revised acetabular component had taken place. Treatment failure was defined as a change of the acetabular component position, steepening, or migration higher than 2 mm when comparing X-ray in the immediate postoperative period with a final radiograph.[8] Furthermore, the presence of solid radiolucent lines larger than 2 mm or progression of radiolucent lines around the acetabulum also characterized treatment failure.[9]

The reliability of the inter- and intraobserver measurement was indicated by the intraclass correlation coefficient (ICC). Next step consisted in comparing whether or not the implant loosened with the size of acetabular failure, using the Mann–Whitney non-parametric method. In addition, the same method was used to compare failure *vs.* age and failure *vs.* gender. In all statistical tests, a 5% significance level was adopted. To determine whether the method used was a predictive factor for failure of the proposed treatment, an ROC curve was used.

Results

For the present study, 38 patients (38 hips) were selected: mean age of 60.5 years (range 29–87 years), 23 females (60.5%) and 15 males (39.5%). Of these, 13 had involvement on the right side (34.2%) and 25 on the left side (65.8%).

According to the Paprosky classification, two hips (5.3%) were classified as type 1; nine (23.7%) as 2A; eight (21.1%) as 2B; six (15.8%) as 2C; ten (26.3%) as 3A; and three (7.9%) as 3B.

Regarding the type of surgery these patients underwent, 33 were first revision arthroplasties (86.8%), four were second revision arthroplasties (10.5%), and one was a third revision arthroplasty (2.6%). The primary cause of arthroplasties was also analyzed: 14 hips had primary osteoarthritis (36.8%), eight had inflammatory disease (21.1%), six had trauma sequelae (15.8%), five had malformation (13.2%), and five had avascular necrosis of the femoral head (13.2%).

Failure in the proposed treatment was observed in ten hips (26.3%): three failures were observed in the avascular necrosis of the femoral head group (30%), three in the inflammatory diseases group (30%), two in the primary osteoarthritis group (20%), and two in the hip malformation group (20%).

Failure in the proposed treatment was related to gender and side within the ten patients with failure after review, six of whom were male (60% of the failures) and four female (40% of the failures); three on the right side (34.2% of the failures) and seven on the left (65.8% of the failures).

The relationship of loosening or migration of the acetabular component with the Paprosky classification indicated that there were no failures in hips classified as Paprosky 1, two failures in hips classified as 2A (20%), no failures in those classified as 2B, two failures in those classified as 2C (20%), six in those classified as 3A (60%), and no failures in those classified as 3B.

Failure of the proposed treatment was compared with the type of surgery that these patients had undergone: eight failures (80%) were observed in patients who underwent first revision arthroplasty, one failure (10%) in a patient who underwent second revision arthroplasty, and one (10%) in the single patient who underwent third revision arthroplasty.

The size of the initial bone lesion ranged from 3 to 37 mm; in this study, patients whose bone lesions were smaller than 11 mm did not present failure of the proposed treatment (Fig. 2).

The validation study comparing the measurements of the three examiners found an acceptable level of intra- and

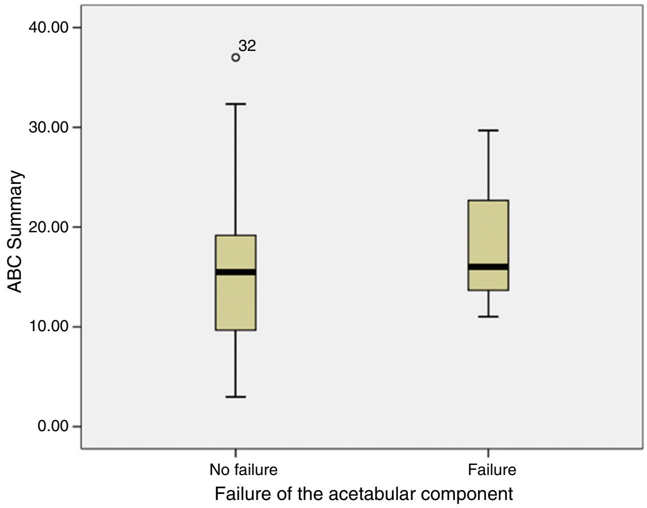

Fig. 2 – Box plot comparing failure of the acetabular component *vs.* size of initial bone lesion.

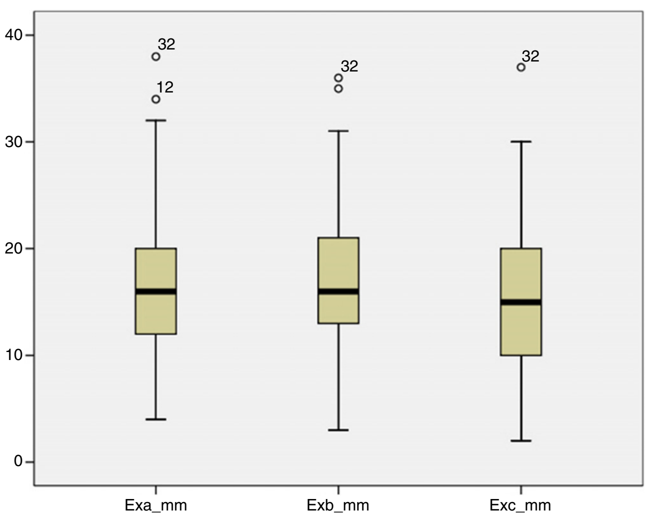

Fig. 3 – Box plot comparing measurements performed by evaluators *vs.* size of the initial bone injury.

inter-observer agreement (ICC > 0.70) between the measurements of the vertical size of the failure, demonstrating the reliability of the method (Fig. 3).

Discussion

Acetabular bone deficiency may be caused by wear, loosening, infection, bone loss at the time of previous surgery, pre-existing fracture, acetabular dysplasia, or even bone destruction during removal of the component or cement. All these factors lead to bone deficiency, which hinders treatment.

Total hip arthroplasty revisions are often associated with loss of acetabular bone stock.[4] In the literature, there are various treatments to manage this problem, but none is fully effective. Treatment aims to provide stability of the implant and restore the joint center of rotation.[10]

These lesions can be treated with bone grafting or larger prostheses, according to the techniques described in the literature.[2,11] The bone grafts used for revision arthroplasties have been an important object of study for some authors,[1–4,11–14] with growing expectations of solving a problem that has no definitive solution yet.

The homograft used for acetabular reconstruction can be divided into two groups: block graft and graft chips. The use of block graft is controversial[10,11] and usually restricted to cases with extended acetabular failure.[12,13] The use of this graft to fill the bone defect has been linked to early failure due to graft absorption and fracture, especially when used as a support system.[14]

In recent studies, Hooten et al.[15,16] have shown that although radiographically the autologous graft appears to be integrated and absorption areas are not observed, therefore indicating an apparent stability of the acetabular component, postmortem histological exams revealed vascularization only on the surface of the graft in contact with host bone. Only peripheral integration was observed, to no more than 2 mm, making the graft an avascular mass without any chance of integration.

The literature shows that graft failure rates increase when using structured grafts to support areas larger than 50% of the acetabular component surface.[15] However, as previously mentioned, the main indication for block grafts are bone defects of greater magnitude, in which over 50% of the surface of the acetabular cup is supported by fresh bone graft.[15]

In a recent study, Bilgen et al.[3] concluded that having at least 50% contact between the acetabular cup and the host bone is not absolutely necessary for a stable construction.

Jasty and Harris[17,18] found no differences between the use of autograft or homograft, considering both forms of graft to have similar efficacy for acetabular bone loss.

Sloof et al.[4] proposed the use of impacted graft chips; their technique has gained wide acceptance and is used in various services. Their study used impacted bone graft chips and obtained 90% good results in a mean follow-up of 11.8 years.

Buttaro et al.[19] assessed 23 revisions, applied the same technique with frozen graft chips with a mean follow-up of 35.8 months, and obtained 90.8% good results. In a recent study, Comba et al.[20] evaluated 30 cases, also with frozen graft chips, with a mean follow-up of 86.5 months and 86% good results.

Buckley et al.[21] analyzed 123 acetabular revision procedures using graft chips with a mean of 60 months, achieving 86% good results. The integration of impacted graft chips has already been reported in studies with histological analysis.[20] The impacted graft chips technique was applied in all patients in the present study.

van Haaren et al.[22] reported a high failure rate of 28% at 7.8 years of follow-up, with the use of impacted grafts for different magnitudes of acetabular failure, including pelvic discontinuity. However, they did not quantitatively establish to which magnitudes of bone defect impacted grafting is correctly indicated.

In the present sample, similar results were observed, with a 26.3% incidence of graft failure at 48 months follow-up with the technique presented for different types of bone injury.

Garcia-Cimbrelo et al.[23] evaluated the acetabular graft lifespan in revision surgeries performed in 165 patients with a mean follow-up of 7.5 years, excluding patients with large

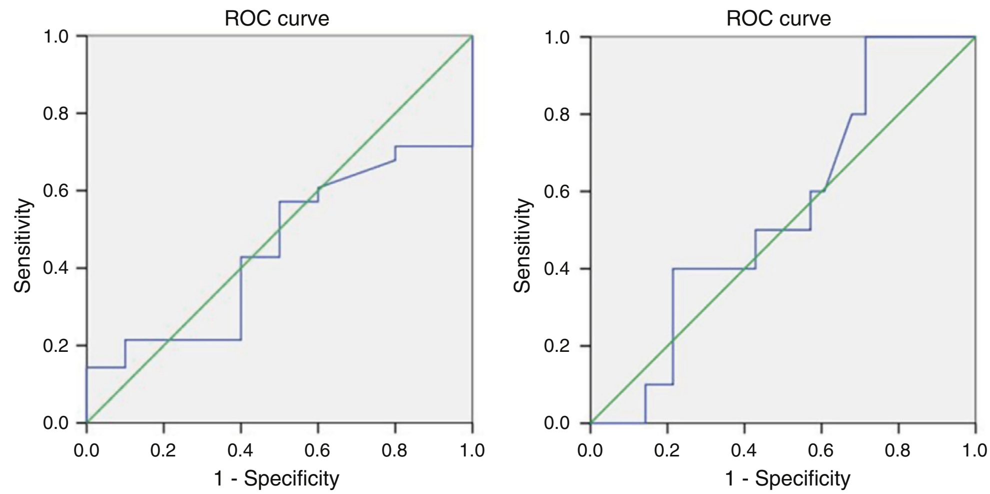

Fig. 4 – ROC curve showing absence of statistical significance in measurement of the vertical size of the lesion *vs.* revision failure.

initial bone loss; they acknowledged the need for cages or plates in larger lesions. However, this magnitude was also not quantified. The present study did not adopt serious lesions as an exclusion criterion, precisely to address the lack of information on the acceptable degree of acetabular bone stock loss for impacted bone graft.

El-Kawy et al.[24] evaluated 28 patients classified as Paprosky type 3 and found 96.4% good results at 72 months of follow-up.

In the present study, the sample was not large enough to statistically correlate the Paprosky rating with the number of failures observed. The analysis of the ROC curve (Fig. 4) shows that the vertical size of the lesion is not an implant failure predictor ($p > 0.05$). However, in a subjective analysis of the data, no revision failures were observed in lesions with initial vertical size lower than 11 mm. The main challenge in this study was surely to find the best way to assess the magnitude of this lesion with only anteroposterior X-rays.

Some limitations of this study are noteworthy. First, some studies have shown the superiority of CT in relation to X-ray to measure acetabular preoperative bone loss.[25,26] However, as the present analysis was retrospective, from 1995 to 2008, the vast majority of patients had no documented tomographic images. Thus, the analysis of hip X-rays in anteroposterior incidence was the method chosen.

Another limitation of the study was the use of a simple X-ray to measure a cavity. It is known that the acetabular lesion is a three-dimensional condition and that its precise measurement in only one radiograph is not possible. However, this study aimed to evaluate the possibility of a quick and easy study, which could be done in the office, to predict a possible failure, as well as to assess whether the measurement of the vertical size of the lesion on simple radiographs was similar in the inter- and intraobserver evaluation.

In this case, as the radiographic evaluation presented a consistent inter- and intraobserver agreement, the authors believe that the results were not compromised.

Finally, authors believe that studies with larger sample sizes are needed to better define the correlation of the failure in this type of treatment with the size of the preoperative bone lesion measured in simple radiographs.

Conclusion

Failure in revision acetabular arthroplasty using impacted graft did not present a statistically significant association with variables described in the present study, demonstrating that the measure of failure in an anteroposterior radiograph cannot be used in isolation as a predictive factor for failure of the acetabular revision, which is confirmed by lack of significance in the ROC curve.

Conflicts of interest

The authors declare no conflicts of interest.

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