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Biomechanical study of pelvic discontinuity in failed total hip arthroplasty. Lessons learnt from the treatment of pelvic fractures

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ABSTRACT

Pelvic discontinuity is a rare but serious problem in orthopedic surgery. Acetabular reconstruction in case of severe bone loss after failed total hip arthroplasty is technically difficult, especially in segmental loss type III (anterior or posterior) or pelvic discontinuity (type IV). Acetabular reinforcement devices are frequently used as load-sharing devices to allow allograft incorporation and in order to serve as support of acetabular implants. This study tries to show, by means of biomechanic work, the efficiency of reinforced plate in anterior column in a segmental pelvic loss, illustrated with a clinical case, which shows the socket stability of hip prosthesis.

Introduction

With the increasing life span of patients living with total hip arthroplasties and a trend toward indicating surgery at younger ages, the volume and complexity of revision surgery will undoubtedly increase. Pelvic discontinuity (PD) is a rare but serious problem in orthopedic surgery. Periprosthetic PD describes the loss of structural bone between the superior and inferior aspects of the pelvis. It is a severe form of acetabular deficiency. In revision hip arthroplasty, PD is due to osteolytic bone loss, and usually represents a chronic stress fracture of the underlying bone. Acetabular reconstruction, in case of severe bone loss after failed total hip arthroplasty, is technically difficult [1–4].

In its classification of acetabular bone loss in patients undergoing revision hip surgery, the American Academy of Orthopaedic Surgeons (AAOS), defined a pelvic discontinuity as a Type-IV deficiency [5]. Posteriorly, different authors have introduced new classifications. The Paprosky's classification is based upon the severity of bone loss and the ability to obtain cementless fixation for a given bone loss pattern [6]. Berry *et al.* subclassified the degree of bone loss associated with PD as Type IVa if the discontinuity is associated with cavitary or mild segmental bone loss, Type IVb if the discontinuity is associated with a large segmental or a combined defect, and Type IVc if the pelvis had been previously irradiated regardless of the presence of cavitary or segmental bone loss [7].

Acetabular reinforcement devices (ARDs) are frequently used as load-sharing devices to allow allograft incorporation and in order to serve as support of acetabular implants in revision hip arthroplasty with massive acetabular loss. If a PD has been ruled out, the options for reconstruction include: (1) nonbiologic fixation with impaction allograft supported with a cage or (2) structural allograft supported with a cage or (3) biologic fixation with a modular trabecular metal system or a custom Triflange. Despite the good results reported, it remains unclear whether any of these construct offer substantial advantages [8–12].

Different algorithmic approaches have been defined at the moment of revision of the acetabulum with a suspected pelvic discontinuity. The initial decision pointed for Berry relates to the superior migration of the hip center before revision [7]. Sporer establishes different attitude if there is or not healing potential. In cases of acute discontinuity (with healing potential), the author proposes: plate with cage and allograft or internal plate with trabecular metal. In chronic discontinuity cases (without healing potential), the alternative is acetabular transplant, trabecular metal with augments and Triflange implants [10].

Despite numerous published studies reporting the case series of various treatment options, to date, no clear consensus to treatment has been proposed. Our goal is to achieve cementless biologic fixation and an alternative reconstruction when insufficient stability was obtainable, as Rogers *et al.* have highlighted [11]. We propose to achieve stability with a plate in anterior column by ilioinguinal

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(Letournel's) approach, using the standard biologic principles of acetabular fracture fixation ("lessons learnt from the treatment of pelvic fractures") [13].

The aim of this study was the direct comparison of the static fixation strength of two constructs with a common plate system, furthermore, the role of the reinforced systems used around this plate. Biomechanical study, with some differences, respects the works carried out for other authors [14–16].

As Gililland pointed out, the study of the initial stability, provided by various constructs, is a vital undertaking in the effort to maximize union rates and minimize complications in difficult cases [16]. Although this author carried out a biomechanical evaluation of three types of constructs, the more interesting for us is the third in his paper, in other words, the novel concept of a cup supported by a column plate. In our case, with a different strategy as Gililland has proposed, with a reinforced plate. We present at the same time a clinical case with this technique.

Materials and methods

Experimental setup

As other authors in biomechanical studies, a pelvic discontinuity model was created in custom artificial osteoporotic composite hemipelvis (Sawbones Hemipelvis, fourth generation, model #3409) [16–19]. Custom-made anterior column discontinuity (gap defect) mimicking lost bone for debris in artificial pelvis was made by an oscillating saw system, filling the gap with foam synthetic bone material. The anterior column gap was fixed with two different acetabular plates of Matta pelvic systems (MPS).

Group I: MPS without reinforcement; group II: MPS with reinforcement (Figure 1). The test was performed five times in each of the hemipelvis in order to determine the stiffness of each of the systems and finally a cycle load was applied to the system failure. We have not made a fracture of the posterior column for two reasons: (1) in order to avoid excessive weakness, (2) our goal was to demonstrate the great stiffness of the second construct (reinforced), in comparison with the former, because the anterior column plate has a higher risk to be displaced into the pelvis without the reinforced method, after the loading of the socket (Figure 2).

Experimental protocol

Each of the hemipelvis was tested under static loading five times, using acetabular reconstruction with anterior column 3.5-mm plate of MPS (Stryker). Reinforced with another crossed proximally plate of four holes and two Dall-Miles (Stryker) wires distally through obturator foramen. When building the constructs, uniformity was critical to provide valid comparisons. After performing the five repetitions of stiffness test, a destructive test of each of the samples is performed for the resistance of each of the constructions (load max.). The approach ending of the trial was the appearance of new synthetic bone fractures.

The test was performed with an ambient temperature of 23°C and 52–54% humidity.

The test was conducted on testing machine INSTRON 8874/135.

The stabilized systems are anchored in the bed of one of the trials leaving free ends and compression forces on each of the systems were applied in such a direction that fostered a remarkable deformation fractures indicated by other authors [20]. Compression loads were applied through a femoral head of 32 mm and the corresponding implanted acetabular cup in the acetabulum of the pelvis by screws (Figure 3).

Each of the pelvis to be tested were subjected to compressive loads applied at a rate of 4 mm/min, up to 70 kg body weight simulating the static of a person.

Data analysis

The stiffness value is determined from the second slope of the curves which measure forces vs displacement during each shift assays.

Clinical case. Surgical technique

Before removal of the socket, we have made a CT angiography in order to define vascular location and major vascular bleeding prevention in context of intrapelvic cup migration [21,22]. The CT showed that none of the significant vessels had a close relationship to the acetabular cup. There were no signs of infection, the inflammatory markers were normal (erythrocyte sedimentation rate [ESR] <10, C-reactive protein [CRP] <6) and scan with gallium negative for

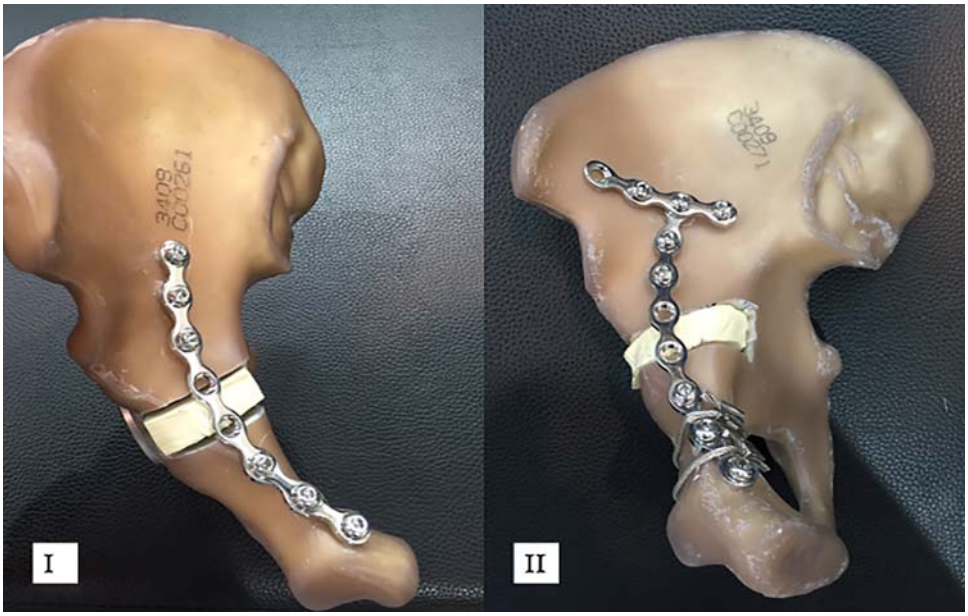

Fig. 1. I: MPS without reinforcement. II: MPS with reinforcement with another crossed proximally plate of four holes and two wires distally through obturator foramen.