USE OF TRABECULAR METAL IN ACETABULAR DEFECTS IN REVISION TOTAL HIP ARTHROPLASTY

Essay

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INTRODUCTION

Total hip arthroplasty is the most commonly performed adult reconstructive hip procedure. [(1)] Over the past several decades, total hip arthroplasty has become recognized as an effective treatment option for the reduction of pain and disability associated with advanced degenerative arthritis and traumatic injuries with successful clinical outcomes [(2)], and because the operation is being performed in younger and more active patients, the number of revision procedures has increased dramatically. [(1)]

In many patients, failure of total hip arthroplasty can be traced to one or more technical problems that occurred at the time of the primary procedure. [(1)] Revision of total hip arthroplasty usually is much more difficult, and the results typically are not as satisfactory as after a primary total hip arthroplasty. Revision requires more operative time and more blood loss, and the incidences of infection, thrombo-embolism, dislocation, nerve palsy and fracture of the femur are higher. [(1)]

Revision total hip arthroplasty is indicated in failure of femoral component and/or acetabular component. Isolated acetabular component revision comprised *12.7%* of all revision hip procedures and instability/dislocation was reported as the most common indication. [(2)]

The indications for acetabular revision surgery include aseptic loosening, malposition, severe polyethylene wear, recurrent dislocation, and infection, with aseptic loosening being the primary reason. [(3)]

The aim of acetabular revision is to repair the bone defect, restore the rotation center to its anatomical position, achieve adequate fixation and stability of the acetabular component and avoid complications. [(3)]

The most important parameter affecting the surgeon's ability to achieve this is bone stock. Bone deficiency is a major challenge in acetabular revision surgery. Bone stock deficiency must be identified and classified to plan appropriately for the surgery.

Classification systems for acetabular defects have been used to present the severity of bone loss that will likely be found intra-operatively, allowing for appropriate selection of reconstructive options. In 1989, *D'Antonio et al* first described what is now commonly known as the American Academy of Orthopaedic Surgeons *(AAOS)* classification system of acetabular abnormalities after total hip replacement. The AAOS classification system distinguishes between segmental and cavitary defects, and also subdivides the presence of pelvic discontinuity. Though widely used in the literature, this classification system does not account for the location or size of acetabular defects. [(2)]

A decade after the introduction of the *AAOS* classification system, *Saleh* et al released results validating the *Gross* classification system, which quantified the extent of contained versus uncontained bone loss and implications related to use of morselized bone graft during revision reconstruction. [(2)]

Perhaps the most widely cited and clinically implemented system, the *Paprosky* Classification, was developed to establish acetabular defect type, size, and location for a collective guidance towards the selection of appropriate reconstructive options for revision surgery. This system was based on four radiographic measures obtained from an anterior-posterior radiograph of the pelvis: superior hip center migration, ischial osteolysis, the position of the implant relative to the Kohler (ilioischial) line, and teardrop osteolysis. Unique to this methodology, defects were classified by type to indicate whether the remaining acetabular structures are completely supportive (Type I), incompletely supportive (Type II), or unsupportive (Type III) of an implanted component. Today, this classification system continues to provide a useful treatment algorithm, even with the availability of a wider variety of modular metal augmentation and reconstruction options. (2)

Evaluation of the acetabular bone deficiencies preoperatively and intraoperatively, using the Paprosky or the American Academy of Orthopaedic Surgeons (AAOS) classification system, is important for acetabular reconstruction. In most cases intraoperative assessment of bone deficiency correlates with the preoperative radiographic evaluation, but in some instances they are not consistent. (4)

Treatment of acetabular component failure and associated bone defects depends on patient characteristics, the degree and location of bone loss, the ability of the columns to support biologic fixation, and the presence of pelvic discontinuity. The ultimate goal of revision acetabular reconstruction should be to obtain stable fixation and restore the hip center. (2)

Large bone defects have raised the need for bone substitution beyond the capacity of autogenous transplants. The current practice for prosthetic reconstitution relies typically on modular metallic devices and bone graft techniques, but the long-term persistent problem is degradation of the interface between the bones and implant.

Biological ingrowth surfaces have become a standard prosthetic element in reconstructive hip surgery. A material's properties, three-dimensional architecture, and surface texture all play integral parts in its biological performance. A porous tantalum biomaterial, Trabecular Metal devices, with similar structure and mechanical properties as bone represents a new option with the potential of enhanced biological incorporation and greater structural integrity as well as provide a structural scaffold in cases of severe bone deficit. (5, 6)

Aim of the Study

The aim of the work is to review the literature regarding the use of porous tantalum in revision of acetabular defects in RTHR.

This is through reviewing different Trabecular Metal components and their applications in different varieties of acetabular bone loss.

Applied Anatomy of Acetabulum

Osteology of the Acetabulum:

The acetabulum is a hemispherical hollow on the outer surface of the innominate bone, formed by the fusion of its three component parts: the ilium, ischium and pubis which meet at a - Y - shaped cartilage forming their epiphyseal junction. The anterior one-fifth of the acetabulum is formed by the pubis, the superior posterior two-fifths by the body of the ilium and the inferior posterior two-fifths by the ischium. The prominent rim of the acetabulum is deficient inferiorly as the acetabular notch. The heavy wall of the acetabulum consists of a semilunar articular part, covered with hyaline cartilage, which is open below, and a deep central non-articular part, the acetabular fossa. The acetabular fossa is formed mainly from the ischium and its wall is frequently thin. [(7)]

The acetabular surface is orientated approximately 45° caudally and 15° anteriorly. The acetabulum has a mostly circular contour in its superior margin, but it has only enough hemispherical depth to allow for 170 degree coverage of the femoral head. Femoral head coverage within the acetabulum is augmented by the labrum, which runs circumferentially around its perimeter to the base of the fovea, where it becomes the transverse acetabular ligament. [(8)]

At first sight the acetabulum appears to be contained within an arch. The limbs of the arch are posterior (or ilio-ischial), and anterior (or ilio- pubic). For a better understanding of the pathological anatomy of the acetabular defects, we must alter somewhat this basic concept of the architecture. It is better to regard the acetabulum as being contained within the open arms of an inverted Y *(Fig. 1)* . [(9)]

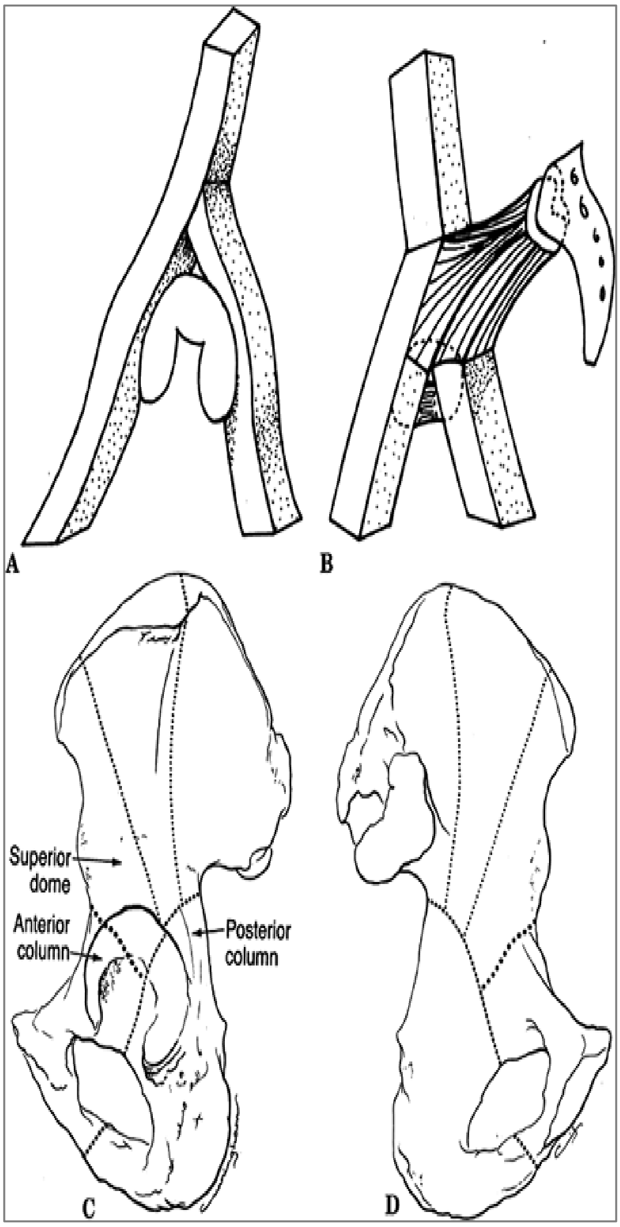

Figure (1): (A) A diagram of the two columns as an inverted Y supporting the acetabulum. (B) The two columns are linked to the sacral bone by the sciatic buttress. (C) Lateral aspect of the hemipelvis and acetabulum. The posterior column is characterized by the dense bone at the greater sciatic notch and follows the dotted line distally through the center of the acetabulum, the obturator foramen, and the inferior pubic ramus. The anterior column extends from the iliac crest to the symphysis pubis and includes the entire anterior wall of the acetabulum. Fractures involving the anterior column commonly exit below the anterior-inferior iliac spine as shown by the heavy dotted line. (D) The hemipelvis from its medial aspect, showing the columns from the quadrilateral plate. The area between the posterior column and the heavy dotted line, representing a fracture through the anterior column, is often considered the superior dome fragment. [(10)]

From its lateral aspect the acetabulum forms an inverted - Y - one limb forming the **anterior column** and one forms the **posterior column**.

The **anterior column** *(Fig.2,3,4)* extends from the iliac crest to the symphesis pubis and includes the anterior wall of the acetabulum. The **posterior column** *(Fig.2,3,4)* begins at the superior gluteal notch and descends through the acetabulum, obturator foramen, and inferior pubic ramus and includes the posterior wall of the acetabulum and ischeal tuberosity. The superior – weight baring area, which includes a portion of both the anterior and posterior columns, has been called the **acetabular dome** or **roof**. [(11)]

The two strong osteal columns of bone surround the acetabulum, transmitting the stresses between the trunk and lower extremities. The columns vary in thickness as they pass around the acetabulum.

In general, expanding the acetabulum more than one third beyond the acetabular diameter (i.e., over reaming the acetabulum) will risk creating a pelvic discontinuity, rendering the columns incompetent. Reaming one quarter of the acetabular diameter is safe, preserving approximately 50% of the cross-sectional bone area of the anterior and posterior columns. [(8)]

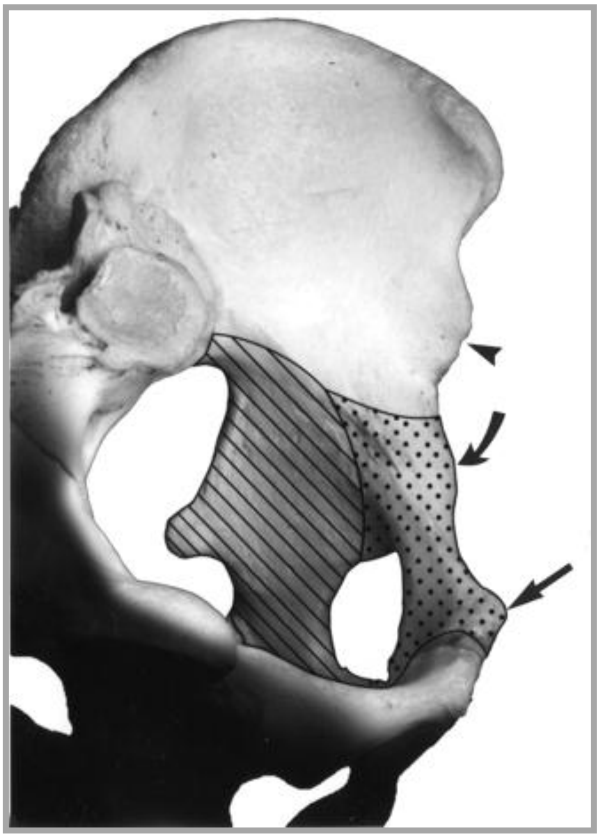

Figure (2): Anatomically defined anterior column of acetabulum. Arrowheads indicate anterior inferior iliac spine; curved arrows, iliopectineal eminence; and straight arrows, pubic tubercle. Schematic representation shows anatomically redefined anterior (*dotted area*) and Letournel-defined posterior (*striped area*) column in internal projection. [(12)]

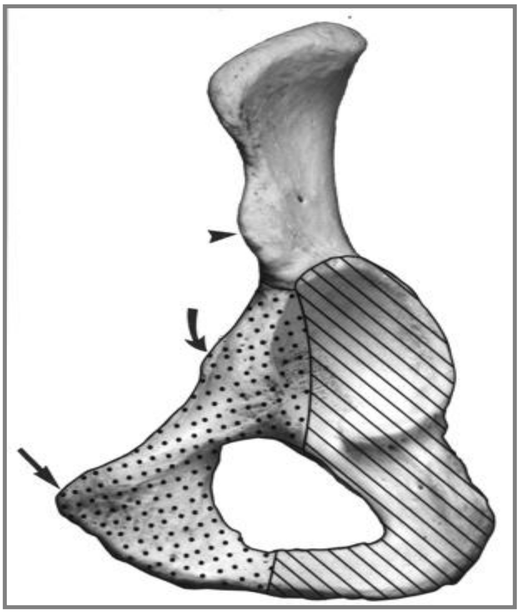

Fig 3

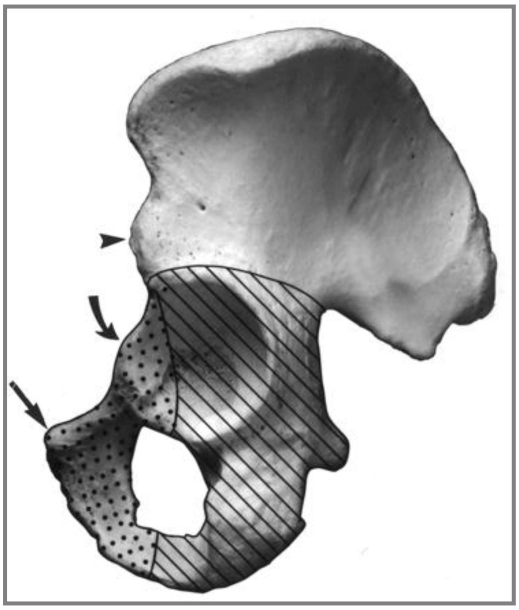

Fig 4

Figure (3): Anatomically defined anterior column of acetabulum. Arrowheads indicate anterior inferior iliac spine; curved arrows, iliopectineal eminence; and straight arrows, pubic tubercle. Schematic representation shows anatomically redefined anterior (*dotted area*) and Letournel-defined posterior (*striped area*) columns in obturator oblique projection. [12]

Figure (4): Anatomically defined anterior column of acetabulum. Arrowheads indicate anterior inferior iliac spine; curved arrows, iliopectineal eminence; and straight arrows, pubic tubercle. Schematic representation shows anatomically redefined anterior (*dotted area*) and Letournel-defined posterior (*striped area*) columns in lateral projection. [12]

Congruence:

Although the articular surfaces of the acetabulum and the head of the femur are reciprocally curved, the hip joint consists of two incongruent shapes. Incongruity implies limited contact between the two surfaces under low loading conditions, with a gradual increase in the area of contact with increasing load. Because of this it is usual to think of the incongruity as a means to distribute load and protect the underlying cartilage from excessive stress. An important factor in the functioning of such a mechanism is the compressibility of the cartilage. The incongruity of the hip joint is determined by an arched acetabulum and a rounded femoral head. [7]