Shoulder Arthroplasty in Cases of Significant Bone Loss: An Overview

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Over the past few decades, there has been a dramatic increase in the number of shoulder arthroplasties performed around the world. This increase is the result of an aging and increasingly more active population, better implant technology, and the advent of reverse shoulder arthroplasty (RSA) for rotator cuff arthropathy. Additionally, as the indications for RSA have expanded to include pathologies such as rotator cuff insufficiency, chronic instabilities, trauma, and tumors, the number of arthroplasties will continue to increase. Although the results of most arthroplasties are good and predictable, any glenoid and/or humeral bone deficiencies can have detrimental effects on the clinical outcomes of these procedures. Bone loss becomes more of a problem in revision cases, and, as the number of primary arthroplasties increases, it follows that the number of revision procedures will also increase.

Many of the disease- or procedure-specific processes indicated for shoulder arthroplasty have predictable patterns of bone loss, especially on the glenoid side. Walch and colleagues¹ and Bercik and colleagues² made us aware that many patients with primary osteoarthritis have significant glenoid bone deformity. Similarly, there have been a number of first- and second-generation classification systems for delineating glenoid deformity in rotator cuff tear arthropathy and in revision settings. In revision settings, both glenoid and humeral bone deficiencies can occur as a result of implant removal, iatrogenic fracture, and even infection. Each of these bone loss patterns must be recognized and treated appropriately for the best surgical outcome.

The articles in this month of The American Journal of Orthopedics address the most up-to-date concepts and solutions regarding both humeral and glenoid bone loss in shoulder arthroplasty of all types.
Humeral Bone Loss

Humeral bone loss is typically encountered in proximal humerus fractures, in revision surgery necessitating humeral component removal, and, less commonly, in tumors and infection.

In many displaced proximal humeral fractures indicated for shoulder arthroplasty, the bone is comminuted with displacement of the lesser and greater tuberosities. In these situations, failure of tuberosity healing may result in loss of rotator cuff function with loss of elevation, rotation, and even instability. Humeral shortening can also occur as a result of bone loss and can compromise deltoid function by loss of proper muscle tension, leading to instability, dysfunction, or both. In addition to possible instability, humeral shortening with metaphyseal bone loss can adversely affect long-term fixation of the humeral component, leading to stem loosening or failure. Cuff and colleagues\(^3\) showed significantly more rotational micromotion in cases lacking metaphyseal support, leading to aseptic loosening of the humeral stem.

Humeral bone loss can also result from humeral stem component removal in revision shoulder arthroplasty for infection, component failure or loosening, and even periprosthetic fracture resulting from surgery or trauma.

For the surgeon, humeral bone loss can create a complex set of circumstances related to rotator cuff attachment failure, soft-tissue balancing effects, and component fixation issues. Any such issue must be recognized and addressed for best outcomes. Best results can be obtained with preoperative imaging, planning, use of bone graft techniques, proximal humeral allografts, and, more recently, modular and patient-specific implants. All of these issues are discussed comprehensively in the articles this month.

Glenoid Bone Loss

Proper glenoid component placement with durable fixation is crucial for success in anatomical total shoulder arthroplasty and RSA. Glenoid bone deformity and loss can result from intrinsic deformity characteristics seen in primary osteoarthritis, cuff tear arthropathy, or glenoid component removal in revision situations and infection. These bone deformity complications can be extremely difficult to treat and in some cases lead to catastrophic failure of the index arthroplasty.

We are now aware that one key to success in the face of moderate to severe deformity is proper recognition. Newer imaging techniques, including 2-dimensional (2-D) computed tomography (CT) and 3-dimensional (3-D) modeling and surgical planning software tools, which are outlined in an upcoming article, have given surgeons important new instruments that can help in treating these difficult cases.

Glenoid bone deformity in primary osteoarthritis was well delineated in the 1999 seminal study of CT changes by Walch and colleagues.\(^1\) The Walch classification system, which characterized glenoid morphology based on 2-D CT findings, was recently upgraded, based on 3-D imaging technology, to include Walch B3 and D patterns (Figure 1).\(^2\) Recognition of certain primary deformities in osteoarthritis has led to increased use of RSA in some cases of Walch B2, B3, and C deformities with substantial glenoid retroversion and/or humeral head subluxation.\(^4\)

In cases of rotator cuff tear arthropathy, glenoid bone deformities are well described with several classification systems based on degree and dimension of bone insufficiency. The Hamada classification system defines the degree of medial glenoid erosion and superior bone loss, as well as acetabularization of the acromion in 5 grades;\(^5\) Rispoli and colleagues\(^6\) defined and graded the degree of medicalization of the glenohumeral joint based on degree of subchondral plate erosion; and Visotsky and colleagues\(^7\) based their classification system on wear.
patterns of bone loss, alignment, and concomitant soft-tissue insufficiencies leading to instability and rotation loss.

In severe glenoid bone deficiency after glenoid component removal, Antuna and colleagues\textsuperscript{8} described the classic findings related to medial bone loss, anterior and posterior wall failure, and combinations thereof.

All these classification systems are based on the 2-D appearance of the glenoid and should be considered cautiously. The glenoid is a complex 3-D structure that can be affected by any number of disease processes, trauma, and surgical intervention. Using more modern CT techniques and 3-D imaging, we now know that many deformities previously classified as unidirectional are, instead, complex and multidirectional.

Frankle and colleagues\textsuperscript{9} developed a classification based more 3-D CT models which has further classified severe glenoid vault deformities in relation to direction and degree of bone loss (\textit{Figures 2A-2E}). Using this system, they were better able to determine degree and direction of deformity than in previous 2-D evaluations, and they were able to determine the amount of glenoid vault bone available for baseplate fixation. Scalise and colleagues\textsuperscript{10} further defined the influence of such 3-D planning in total shoulder arthroplasty.

With knowledge of these classification systems and use of contemporary imaging systems, shoulder arthroplasty in cases of severe glenoid deficiency can be more successful. Potentially, we can improve outcomes even more in the more severe cases of bone loss with use of patient-specific planning tools, including the guides and patient-specific implants that are now readily available with many implant systems.\textsuperscript{11}

Preoperative planning tools, bone-grafting techniques, augmented and specialized glenoid and humeral implants, and patient-specific implants are discussed this month to give our readers a comprehensive review of the latest concepts in shoulder arthroplasty in cases of significant bone loss or deformity.

This month of \textit{The American Journal of Orthopedics} presents the most current and cutting-edge solutions for humeral and glenoid bone deformities and deficiencies in contemporary shoulder arthroplasties.

\textbf{Key Info}

\textbf{Figures/Tables}

Figures / Tables:

\textit{dines.jpg}
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References


**Multimedia**

**Product Guide**

- Med4 Elite®
- GRPro 2.1®
- Shoulder Wrap
- Knee Wrap

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