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Glenoid Component Design and Fixation in Total Shoulder Arthroplasty

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Glenoid component loosening is one of the most common complications of total shoulder arthroplasty. It accounts for poor functional outcome, persistent pain, and increased chance of reoperation. Many factors contribute to this phenomenon, including limited glenoid bone, especially in the setting of erosion characteristic of osteoarthritis and inflammatory arthropathies, and joint-reactive forces inherent to the shoulder joint. A great deal of research has been done in the areas of component design and implantation technique. We advocate careful glenoid preparation and pressurized cementing technique of all-polyethylene pegged or keeled glenoid components with specialized instrumentation in the majority of cases. We have narrower indications for newer, ingrowth tantalum components.

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Total shoulder arthroplasty has become a common treatment for degenerative and inflammatory arthritis of the glenohumeral joint. Although survivorship is high, one of the most common modes of failure is loosening of the glenoid component.[1] It can be responsible for early aseptic loosening and can lead to shoulder pain and compromised function. Often, reoperation is necessary to successfully treat the construct failure.

There are many reasons why fixation of the glenoid component represents such a challenge to shoulder surgeons. One important reason is that in both osteoarthritis and inflammatory arthropathies, such as rheumatoid arthritis, the glenoid bone stock can be limited.[2] At baseline, the glenoid is a small anatomic feature of the scapula, making fixation to it difficult under any circumstance. Osteoarthritis of the shoulder can be characterized by marked eccentric posterior wear of the glenoid, which not only presents a challenge in restoration of proper version but also can further complicate the process of prosthetic fixation. Rheumatoid arthritis is characterized by glenoid bone erosion as well, although it tends to present as centralized erosion. Again, the amount of bony destruction, as well as typically poor bone quality, can make component fixation difficult and tenuous. Another reason that glenoid components tend to loosen over time is the amount of force exerted on them by movements at the glenohumeral joint.[3] The mobility and joint-reactive force of the glenohumeral joint and design features of some glenoid components contribute to these forces.[4]

Because glenoid component loosening is such an important mode of failure in total shoulder arthroplasties, component design and fixation technique are areas of intense research. We present some of the recent developments in these areas as well as our own experience and rationale for our current selection of implants and fixation techniques.

Improvements in Glenoid Component Design

Glenoid component radius of curvature is a design feature that has undergone substantial evolution. The two basic types of glenoid component curvatures consist of conforming and nonconforming (Fig. 1). Conforming glenoid implants match the radius of curvature of the humeral head component. They reduce point contact at the head–socket interface, but as the humerus translates on the glenoid, they can allow edge loading, which exerts a rocking force on the fixation between the glenoid component and the bony glenoid platform, which can lead to loosening. Nonconforming implants allow for such translation, but also allow point contact of the

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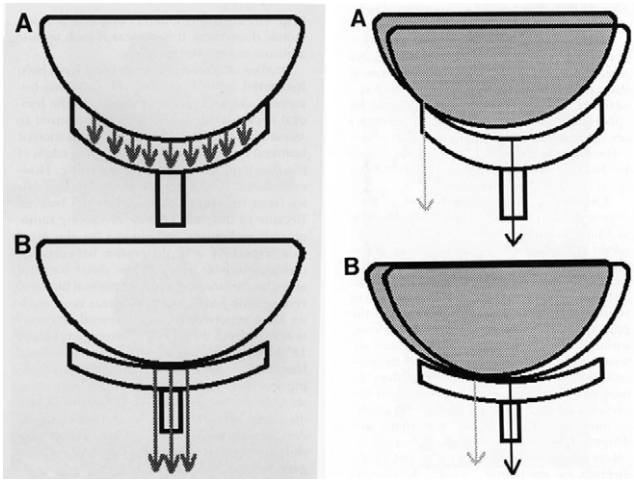

Figure 1 Conforming glenoid design showing lower point contact, but higher edge loading with translation (A). Nonconforming design showing higher point contact but more tolerance for translation (B).

humeral head, which can produce higher amounts of polyethylene debris.[5] This debris is then phagocytosed by macrophages, which can also cause osteolysis and component loosening. Some newer systems use dual-radius glenoids that are conforming centrally and nonconforming peripherally to mitigate the problems of each (Fig. 2).

Another design feature is the type of osseous anchor. Some implants use a keel, and others use pegs (Fig. 3). Furthermore, some pegs are in line, and some are out of line. Studies comparing pegs and keels are variable. One radiostereometric analysis of glenoid component migration showed significantly more migration in keeled implants than pegged in certain planes. The differences were increased in the presence of bony erosion of the glenoid.[6] A radiographic analysis of

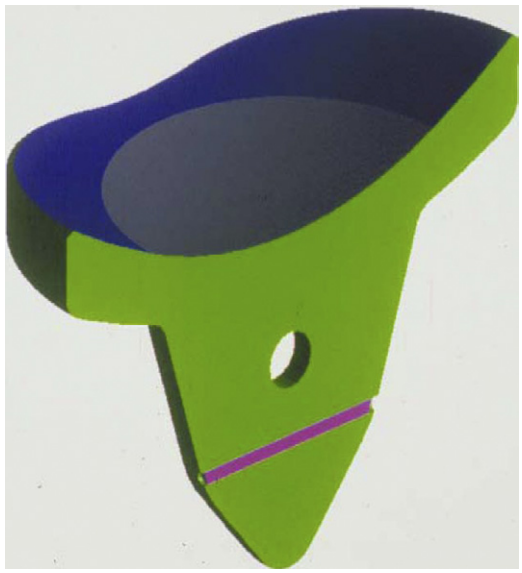

Figure 2 Dual-radius glenoid implant with central conforming zone and peripheral nonconforming zone. (Color version of figure is available online.)

Figure 3 Pegged and keeled glenoid component designs.

different component designs showed 39% of keeled implants to have radiolucent lines on initial x-ray compared with 5% in the pegged group.[7] A more recent prospective study using modern cementing technique showed a trend of more radiolucency with keels on initial radiographs that did not reach statistical significance. However, on subsequent radiographs at an average of 26 months, this trend continued and became statistically significant.[8] Finite element analysis has demonstrated pegged components to be more stable in normal bone, whereas keeled components were more stable in rheumatoid bone.[9] A recent radiographic analysis showed that radiolucency develops over time regardless of peg configuration; however, there was no significant difference between pegs and keels.[10] Another recent study did not reveal significant radiographic, radiostereometric, or clinical differences between keeled and pegged implants at 2-year follow-up.[11]

Improvements in Glenoid Fixation Technique

In addition to advances in technology, there have been advances in the technique of glenoid component fixation. Methods of glenoid bone preparation and cement application aim to increase longevity and lower reoperation rates.

Historically, the bony platform of the native glenoid was prepared by hand without specialized instrumentation. Cement was applied manually before implant insertion. More modern techniques include pulse lavage, sequential drying of the bone with thrombin- and peroxide-soaked sponges, and compressed gas lavage.[12,13] Additionally, the use of punches specifically designed for the peg or keel configuration has been introduced (Fig. 4). One study showed superior results with a keel punch than with curettage of the keel hole. The conclusion was that a stronger bony support is produced with bone impaction when compared with methods that remove bone. It was also found that the size match between the punch and the keel of the implant allows less initial toggling.[14]

Cement technique has also undergone investigation and modification. Rather than finger packing, modern cementing technique emphasizes multiple syringe injections and pressurizations. Syringe application has been shown to produce