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The ability of massive osteochondral allografts from the medial tibial plateau to reproduce normal joint contact pressures after glenoid resurfacing: the effect of computed tomography matching

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Background: Current techniques for resurfacing of the glenoid in the treatment of arthritis are unpredictable. Computed tomography (CT) studies have demonstrated that the medial tibial plateau has close similarity to the glenoid. The purpose of this study was to assess contact pressures of transplanted massive tibial osteochondral allografts to resurface the glenoid without and with CT matching.

Methods: Ten unmatched cadaveric tibiae were used to resurface 10 cadaveric glenoids with osteochondral allografts. Five cadaveric tibiae and glenoids were CT matched and studied. An internal control group of 4 matched pairs of glenoids, with the contralateral glenoid transplanted to the opposite glenoid, was also included as a best-case scenario to measure the effects of the surgical technique. All glenoids were tested before and after grafting at different abduction and rotation angles, with recording of peak contact pressures.

Results: Peak contact pressures were not different from the intact state in the autografted group but were increased in both allografted groups. CT-matched tibial grafts had lower peak pressures than unmatched grafts. Peak pressures were on average 24.8% (range [18.3%, 29.6%]) greater than in the native glenoids for unmatched allografts, 21.8% ([17.0%, 25.5%]) greater for the matched allografts, and 4.9% ([3.8%, 5.5%]) greater for matched autografts.

Conclusion: Osteochondral grafting from the medial tibial plateau to the glenoid is feasible but results in increased peak contact pressures. The technique is reproducible as defined by the autografted group. Contact pressures between native and allografted glenoids were significantly different. The clinical significance

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remains unknown. Peak pressures experienced by the glenoid seem highly sensitive to deviations from the native glenoid shape.
Level of evidence: Basic Science, Biomechanics.

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Treatment of shoulder arthritis in patients younger than 50 years remains controversial. Total shoulder arthroplasty has limitations in this age group and is frequently avoided because of concerns of premature glenoid component failure. Therefore, a number of joint-preserving, biologic procedures have been attempted, the majority of which have involved nonanatomic soft tissue interpositions to resurface the glenoid. The results of these procedures are generally inconsistent and have not been durable, leading researchers to consider more anatomic reconstruction options.[1,2,5,6,8,19,22]

Anatomic cartilage resurfacing procedures, such as osteochondral grafting, have had good results in the knee, elbow, and shoulder and have demonstrated re-creation of native biomechanics when graft placement is flush.[14,17] However, osteochondral grafting is not as well studied or established in the shoulder. This is, in part, due the large defect sizes often encountered in glenohumeral osteoarthritis that necessitate massive grafts and the difficulty in obtaining glenoid allografts due to limited supply and the considerable risk of infection during procurement. Therefore, alternative graft sources have been used. Rios et al[23] and Gupta et al[15] have shown that the medial tibial plateau is similar in size and curvature to the glenoid when it is assessed with computed tomography (CT) scans, and thus this could be a potential source for osteochondral grafts for glenoid reconstruction. Despite a lack of preclinical data, some surgeons have been using single allograft plugs from the medial tibial plateau or lateral tibial plafond for local glenoid resurfacing.[16] In a study by Gobezie et al,[12] fresh tibial plateau grafts were used to resurface the glenoid as part of a biologic total shoulder replacement, although the grafts were not size and curvature matched to the glenoid and only partially resurfaced the glenoid. Clinical follow-up was also limited to only 1 month, so the longevity of the grafts and the long-term clinical outcomes of this procedure are unknown. Furthermore, it remains unknown whether osteochondral grafting of the glenoid could compromise subsequent glenoid prosthetic replacement. Small plugs may be insufficient to treat the cartilage loss in many cases, and there have been no reports of resurfacing of the entire glenoid with hyaline cartilage.

The purpose of this study therefore was to assess contact pressures of transplanted massive osteochondral allografts harvested from the medial tibial plateau to resurface the glenoid. In addition, CT matching was used to determine if this would improve biomechanical results. Intact glenoids were compared with glenoids grafted with unmatched medial tibial plateaus and CT-matched medial tibial plateau grafts. The precision of the surgical technique was assessed by transferring the contralateral glenoid as the donor to the opposite glenoid as the recipient in a right and left matched pair to serve as an internal control. The principal outcome measure was peak contact pressures relative to the native intact state. Secondarily, we evaluated the stability of the grafts by qualitative measures.

Materials and methods

Specimen preparation

Nonmatched allografts (group 1)

Ten fresh frozen shoulders (6 female, 4 male) with a mean age (standard deviation [SD], range) of 56.6 years (10.2, 33-65) without evidence of osteoarthritis were dissected free of all soft tissue. An oscillating saw was used to osteotomize the scapulae perpendicular to the glenoid surface, 5 cm distal to the glenoid. The humeri were osteotomized 15 cm distal to the surgical neck. The scapulae and humeri were then potted in polymethyl methacrylate (Fricke Dental International Inc., Streamwood, IL, USA) with use of cylindrical molds. The glenoid surfaces were aligned parallel to the base. The humeri were potted 2 cm proximal to the surgical neck to minimize bending moments. Ten medial tibial plateaus (3 female, 7 male) with a mean age (SD, range) of 51.5 years (9.6, 28-62) were dissected free of all soft tissue and matched to each glenoid on the basis of macroscopic observations of similar size and curvature. Two specimens were later excluded because of fracture of the humerus during biomechanical testing (Table I).

CT-matched allografts (group 2)

On the basis of prior CT studies,[15,23] matching of the radius of curvature was performed to minimize the incongruencies of the surfaces. By use of three-dimensionally (3D) reconstructed CT scans (Aquilion Premium; Toshiba America Medical Systems, Inc., Tustin, CA, USA), the surface curvatures of 8 glenoids and 12 tibial plateaus were assessed according to the method described by Rios et al[23] (Fig. 1). The 5 best matching pairs of glenoids and medial tibial plateaus were selected and prepared as described before. The mean age (SD, range, gender) was 44.8 years (13.0,