Restoration of Articular Geometry Using Current Graft Options for Large Glenoid Bone Defects in Anterior Shoulder Instability

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Purpose: The purpose of this cadaveric study was to compare standard and modified coracoid transfer procedures, bicortical and tricortical iliac crest autografts, and tibial plafond and glenoid allografts with respect to glenoid surface curvature restoration. **Methods:** Computed tomography scans of 8 cadaveric shoulders were acquired in 9 conditions: (1) intact, (2) 25% width defect, (3) classic Latarjet, (4) modified congruent-arc Latarjet, (5) tricortical iliac crest inner table, (6) outer table, (7) bicortical iliac crest, (8) distal tibia, and (9) glenoid allograft. Outcome measures included articular surface area, width, depth, axial and coronal radius of curvature, and subchondral articular step-off, analyzed in bone and soft-tissue window. **Results:** Reconstruction of the articular surface area was optimal with the glenoid allograft (99.4%), classic Latarjet (97.4%), and iliac crest bicortical graft (93.2%). Depth was best restored by the congruent-arc Latarjet (101.0%), tibial (98.9%), and glenoid (95.3%) allografts. Axial curvature was closely matched by the glenoid allograft (97.5%), classic Latarjet (108.7%), and iliac bicortical graft (91.2%). Coronal curvature was most accurately restored by the glenoid allograft (102.6%), the tibial allograft (115.0%), and the classic Latarjet (55.9%). The articular step-off was smallest using the glenoid allograft. **Conclusions:** Overall, glenoid allografts most accurately restored articular geometry. Alternative grafts provided restoration of some parameters but not others. Classic Latarjet performed well in axial and coronal curvature on average but exhibited large variability. Tibial allograft produced the poorest results in axial curvature, despite excellent coronal curvature reconstruction. The congruent-arc Latarjet did not restore the axial curvature accurately and overcorrected coronal curvature. Graft geometry must be weighed against availability, morbidity, and the role of additional stabilizers. **Clinical Relevance:** Accurate graft morphology may help prevent postoperative osteoarthritis. Grafts differ significantly regarding geometric parameters. The findings of this study will help surgeons select the most appropriate graft for glenoid reconstruction.

Glenoid bone loss is a major risk factor for recurrent anterior shoulder instability and for failure of soft-tissue repair.[1,2] Bristow-Latarjet type coracoid transfer procedures have shown excellent long-term clinical outcomes and significantly lower recurrence rates than capsulolabral repairs.[3-5] However, progressive osteoarthritis develops in a number of individuals after coracoid transfer procedures. This has been attributed, at least in part, to suboptimal geometric restoration of the articular surface, leading to altered glenohumeral kinematics and contact mechanics.[6-9]

Several autogenous and allogeneic bone graft sources and techniques have been proposed as alternatives to Bristow-Latarjet coracoid transfer procedures in an effort to improve restoration of articular glenoid congruity. Additionally, reconstructive techniques using free bone grafts avoid demanding surgical steps such as coracoid process harvesting and conjoined tendon mobilization, which significantly increase the risk of complications and

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the learning curve.[10-15] Few studies have analyzed how these alternative reconstructive techniques compare in terms of accuracy of glenoid restoration,[6,7,16] and to date, none have included glenoid allografts or graft cartilage in the morphologic analysis.

The purpose of this cadaveric study was to compare standard and modified coracoid transfer procedures, bicortical and tricortical iliac crest autografts, and tibial plafond and glenoid allografts regarding glenoid width, surface area, depth, joint surface curvature restoration, and subchondral bony step-off by analyzing computed tomography (CT) models obtained in each experimental condition. We hypothesized that free bone grafts would restore glenoid morphology closer to the original state compared with coracoid transfer procedures.

Methods

Anatomic Specimens

Eight unpaired fresh frozen male human cadaver shoulders (4 right and 4 left shoulders) were obtained from our institution's anatomical bequest program after Institutional Review Board approval for this study. A total of 16 specimens were originally screened by clinical inspection, review of medical charts, and fluoroscopic evaluation. Inclusion criteria were male specimens with a maximum age of 75 years. Exclusion criteria were the presence of degeneration, trauma, dysplasia, previous instability, or surgery. Eight specimens exhibiting such signs were excluded from the study. The mean age of the selected 8 donors was 67.9 years (range, 53 to 75 years), mean height was 174.4 cm (range, 165 to 185 cm), and mean weight was 85.5 kg (range, 54 to 113 kg). All soft tissues were removed from the cadaveric specimen, except for the glenoid cartilage and labrum. The scapulae were potted in resin and positioned on a custom tray for manipulation and imaging. Eight ipsilateral iliac crests and distal tibias were harvested from 8 unrelated male donor specimens for reconstructive graft procurement as described below (the mean age of these donors was 70.6 years, with a mean height of 177.5 cm and a mean weight of 89.7 kg).

Experimental Conditions

After scanning each intact scapular specimen as detailed below, an anterior glenoid defect was created. A line was drawn from the supraglenoid to the infraglenoid tubercle. Perpendicular to this axis, the maximal anteroposterior (AP) diameter was measured with digital calipers. A second parallel superoinferior (SI) line was drawn at the anterior 25% of the AP width. A 25% anterior glenoid bone defect was then created with an oscillating sagittal saw along this line (Fig 1).[17-19]

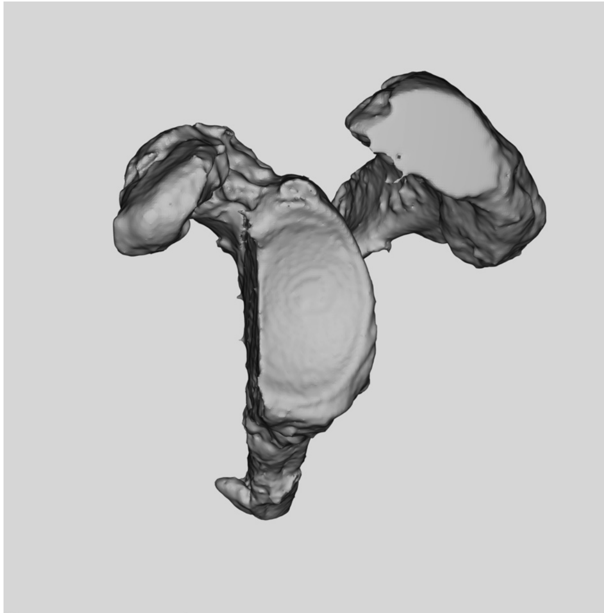

Fig 1. Example of a 3D "cartilaginous" reconstruction of a left glenoid after creation of an anterior 25% glenoid defect parallel to the superior-inferior axis.

Afterwards, the articular surface was reconstructed in 7 sequential conditions: (1) classic Latarjet, (2) modified congruent-arc Latarjet (CA Latarjet), (3) tricortical iliac crest inner table and (4) outer table, (5) bicortical iliac crest, (6) distal tibia, and (7) glenoid osteochondral graft.

The CA Latarjet modification, as described by Burkhart et al.,[20] was performed first, making the curved inferior coracoid side the new articular surface. The classic Latarjet required decortication of the inferior coracoid side and was thus performed afterwards. The graft was positioned so that the lateral cortex aligned with the glenoid face as described by Mizuno et al.[21] and Young et al.[22]

For the iliac crest conditions, a 2 cm long, 1 cm high tricortical iliac crest graft was positioned such that the inner table cortex became an extension of the glenoid surface.[23] The graft was then repositioned to align the outer table cortex with the joint surface for the outer crest condition. The tricortical graft was subsequently split along the crest, and the outer table was used for the bicortical condition as described by Rockwoord and Matsen, using the distal cancellous surface to reconstruct the articular face.[24]

The distal tibia osteochondral graft was harvested from the ipsilateral tibial plafond of an extraneous donor. A graft was taken from the lateral third of the articular surface as described by Frank et al.[25] and Provencher et al.[26]

For the final condition, the previously osteotomized anterior glenoid fragment of one of the other 7 scapulae was affixed to the specimen's glenoid neck. The source