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Feasibility of an osteochondral allograft for biologic glenoid resurfacing

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Background: Concerns regarding insufficient press fit and glenoid vault cortical blowout make glenoid osteochondral allografting uncommon. We used 3-dimensional computed tomography modeling to test glenoid osteochondral allografting feasibility.
Materials and methods: Sixteen cadaveric shoulders without osteoarthritis underwent computed tomography scans to create 3-dimensional models. The diameter of circular center-based reaming reaching the medial endosteal surface at depths of 4, 6, and 8 mm and the clock face position of the most shallow points were calculated. Demographic factors associated with graft diameter were analyzed by step-wise multiple regressions.
Results: Shallower graft depths allowed larger graft diameters ($P < .001$). With a graft depth of 4 mm, 56% of glenoids allowed 20-mm-diameter grafts and 94% accommodated 16-mm grafts versus 31% and 75%, respectively, for a graft depth of 6 mm and 13% and 38%, respectively, for a graft depth of 8 mm. Increasing graft depth decreased graft glenoid coverage: mean coverage was 51.9% ± 12.2%, 36.3% ± 12.9%, and 23.8% ± 14.2% for 4-, 6-, and 8-mm depths, respectively. The glenoid's most shallow point was between the 1:30 clock face position and 3-o'clock position in reference to a right shoulder in 69%, 75%, and 44% of glenoids for 4-, 6-, and 8-mm depths, respectively. Although female gender, patient height, and glenoid height and width were associated with graft diameter, multiple regression analysis showed that patient height was the only independent variable associated with accommodated graft diameter at depths of 4, 6, and 8 mm ($P = .001$, $P = .001$, and $P = .003$, respectively).
Conclusion: Most glenoids support center-based grafts of 16 to 20 mm in diameter at a depth of 4 mm, covering an average of 51.9% of the glenoid. Accommodated graft size decreases as reaming depth increases.
Level of evidence: Basic Science Study, Anatomy, Cadaver Imaging.

Keywords: Glenoid; osteochondral allograft; cadaveric study; computed tomography; glenoid-chondral lesion; 3-dimensional

Shoulder pathology such as isolated chondral defects, chondrolysis, osteoarthritis, post-traumatic arthritis, and instability arthropathy can cause shoulder pain and disability in young active patients.[1] Glenoid cartilage loss is discovered in 5% to 17% of diagnostic arthroscopies, although in

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No institutional review board approval is necessary for cadaveric studies at our institution.

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many cases the contribution of the glenoid lesion to patient symptomatology is unclear.[7,9,17] In the young active patient, surgical management of symptomatic glenoid chondral lesions is controversial, with outcomes poorly reported in the literature. Management may depend on multiple factors including the presence or absence of bipolar disease, patient age, activity level, expectations, and concomitant shoulder pathology.

For patients unresponsive to nonoperative management including activity modification, physical therapy, nonsteroidal anti-inflammatory medications, and corticosteroid injections,[1,7] surgical treatment can be considered. Although total shoulder arthroplasty has predictable outcomes in older patients, younger patients have up to a 38% incidence of glenoid component failure within 10 years of follow-up.[21] Non-arthroplasty options for young active patients are limited to debridement, capsular release, microfracture, ream and run, autologous chondrocyte implantation, and osteoarticular grafting procedures.[1,2,8,13,18,23] Biologic glenoid resurfacing using anterior capsule, autogenous fascia lata, and lateral meniscal allograft[16] and Achilles tendon allograft can also be considered.[14]

Osteochondral allograft transplantation to the glenoid may be a viable alternative to current treatment methods. Though successful in other joints, press-fit osteochondral allografting of the glenoid has been described only in a few cases.[2,13,18] Concern exists as to whether adequate depth to achieve a stable press fit may result in cortical blowout during reaming. The purpose of this study was to use 3-dimensional (3D) computed tomography (CT) modeling of cadaveric glenoids to determine the maximum graft diameter possible based on a given reamer depth. We elected to study depths of 4, 6, and 8 mm based on a recent biomechanical study that showed glenoid osteochondral allograft press-fit stability with a reaming depth of 4 mm.[10] We hypothesized that as the depth of glenoid reaming increased, the corresponding osteochondral allograft diameter size would become significantly smaller.

Materials and methods

Computed tomography

Nineteen fresh-frozen cadaveric shoulders (Anatomical Service, Schiller Park, IL, USA) were obtained. Demographic data including patient height, weight, age, cause of death, race, and gender were available for each cadaver. Each cadaveric shoulder underwent CT scanning in a General Electric Bright Speed 16 scanner (General Electric Healthcare USA, Waukesha, WI, USA). Raw axial images were obtained in 0.625-mm increments with the following settings: 120 kV, 260 mA, and 512 × 512 matrix. After inspection of the CT images, 3 samples were excluded from further analyses: 2 for radiographic signs of degenerative joint disease and 1 for evidence of widely metastatic blastic lesions. For each of the remaining 16 scans, a combination of thresholding using pixel intensity, region growing, and manual mask manipulation was used to create a mask for the scapula by use of Mimics (Materialise, Plymouth, MI, USA) (Fig. 1). Automated reconstruction of this mask created a freestanding 3D volumetric image of the scapula, on which a plane was fit to the face of the glenoid as previously described.[4] New “anatomic” axial, coronal, and sagittal slices were created perpendicular to this plane (Fig. 2).

Sample measurement

All measurements were taken from the anatomic slices. By use of the best-fit circle method,[4,11] the 3D location (axial, coronal, and sagittal coordinates) of the center of the glenoid best-fit circle was measured. In addition, we measured the width of the glenoid (in millimeters), as measured on the axial image at the level of the glenoid center; the height of the glenoid (in millimeters), as measured on the coronal image at the level of the glenoid center; the 3D location of most inferior point on the glenoid; and the 3D location of the most superior point on the glenoid.

To simulate reaming for an osteoarticular graft, two sets of 4-, 6-, and 8-mm-long lines were drawn perpendicular to the plane of the glenoid on each slice. These lines were drawn at the anterior and posterior aspects of the glenoid with the medial aspect intersecting the subchondral bone and the lateral aspect intersecting the endosteal surface of the glenoid vault. The 3D location of the subchondral intersection was recorded for each slice, resulting in 6 data points for each slice (Fig. 3, *A*). These data were then plotted on the en face glenoid view (Fig. 3, *B*).

All 3D data point analyses was performed in Excel X (Microsoft, Redmond, WA, USA). The radial distance between the glenoid center and the subchondral location of each depth measurement was then calculated. The clock face location of each of these points was also calculated based on a right glenoid as our reference, with 12 o’clock set as the most superior aspect of the glenoid as visualized on the en face view. These data were used to determine the location at which a center-based coring reamer would violate the back wall of the glenoid and the size of reamer with which this violation would occur. In addition, for each sample, the largest size of reamer that could be used to obtain graft depths of 4, 6, and 8 mm based on the reamer sizes available in one commonly used commercially available operative instrument set (Osteoarticular Allograft Set; Arthrex, Naples, FL, USA) was determined. The chondral surface area of a graft of this size was then compared with the surface area of the glenoid for each patient as determined by use of a best-fit circle method to calculate the percent of the articular surface covered by the largest available graft.

Statistical analysis

All statistical analyses were performed in SPSS 18 (IBM, Armonk, NY, USA). Kolmogorov-Smirnov testing confirmed nonnormal data distribution, and thus nonparametric tests were used. Kruskal-Wallis tests were used to compare glenoid width, glenoid height, patient age, patient height, and patient weight between genders. Friedman 2-way analysis-of-variance testing was performed step-wise to determine the effect of changing depth on the shortest radial distance. Step-wise multiple regression analyses were used to determine the correlation between glenoid height, glenoid width, patient age, patient weight, and patient height and the shortest radial distance at a depth of 4, 6, and 8 mm.