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ORIGINAL ARTICLE

Mapping of glenoid bone loss in recurrent anterior shoulder instability: is there a particular deficit pattern?

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Background: Glenoid bone loss in recurrent anterior shoulder instability is a challenging problem for shoulder surgeons, and knowledge about the anatomy of glenoid deficits is scarce. In this study, we tried to evaluate the pattern of this pathology.

Methods: Our analysis included 44 shoulders from 44 patients with recurrent anterior shoulder instability accompanied by a clinically relevant glenoid bone loss. The defect size, the localization of the inferior defect edge, and the defect angle were measured, and osseous landmarks were identified. An en face view on 2-dimensional computed tomography scans of each patient was fitted onto a template to create a deficit map for small (<23%) and large (>23%) defects.

Results: The study cohort consisted of 9 women and 35 men with a mean age of 33 ± 11 years at the date of the scan. The defect size and localization of the inferior defect edge showed significant differences between both groups, indicating a more posterior position of larger defects. The defect angle, however, showed no significant difference between small and large defects. Both groups showed a vertical defect pattern.

Conclusion: The osseous glenoid deficit in recurrent anterior shoulder instability shows a vertical pattern with no remarkable differences between small and large defects. This finding can influence biomechanical models as well as surgical reconstruction.

Level of evidence: Basic Science; Anatomy Study; Imaging

Keywords: Shoulder; instability; deficit pattern; CT scan; template; map

Although a great number of patients are treated with procedures that include stabilization of soft tissue, such as the labrum, others show a relevant amount of bony glenoid loss that requires attention in order to impede recurrence with further surgical intervention. As a guideline to identify large osseous deficits, Burkhart et al[3,8] described the inverted pear configuration of the glenoid, which is constituted by a compression defect of the inferior part of the glenoid. In addition to open procedures, arthroscopic techniques are gaining relevance because they show good functional and cosmetic results.[11,12] Apart from the Latarjet procedure, which includes a transposition of the coracoid process to the ventral glenoid, arthroscopic bone graft transfer techniques are being used.[10,11]

No ethical review statement was necessary for this study according to §15 of the Code of Medical Ethics of the Medical Association of North Rhine.

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The primary aim of all these methods is the restoration of native bone configuration on the glenoid. However, whether the osseous deficit caused by repetitive dislocations shows a specific pattern remains unclear. Previous biomechanical studies suggested a straight line at a 45° angle in order to simulate a bony deficit.[7] Yamamoto et al[16] worked with 2-mm enlargements of the defect width by dissecting the anterior rim vertically. The aim of this study was to identify the shape and angle of osseous glenoid deficits as they are seen in daily clinical practice and to compare them to the models used.

Patients and methods

Computed tomography scan analysis

Between September 2009 and October 2016, 65 patients presented at our hospital with recurrent anterior shoulder instability accompanied by a clinically relevant glenoid bone loss. Of these patients, 20 presented only with magnetic resonance imaging (MRI) scans and were excluded from further analysis. The computed tomography (CT) scan for 1 patient could not be retrieved due to technical reasons. Finally, 44 shoulders from 44 patients were included in the analysis.

In a first step, the scans were analyzed at a digital working station using JiveX Review Client 4.4.5 software (VISUS Technology Transfer GmbH, Bochum, Germany). All scans were performed with 128-slice CT scanners in head-first position, using 3-mm slices from 1 cm superior to the shoulder to 1 cm inferior to the scapula.

The slice depicting the full amount of the osseous defect in the parasagittal plane was identified for each shoulder. As described by Hamamoto et al,[6] the defect size was measured using the "surface area method." Afterwards, bony landmarks were identified as described in a previous work.[5] The most posterior point of the bony glenoid cavity (*B*; Fig. 1, *A*) was marked, and a line was drawn between B and the center of the manually applied perfect circle (*c*). The meeting point between this line and the bony deficit was marked (*d*; Fig. 1, *A*). Another line was drawn between *d* and the interface of the superior bony deficit and the perfect circle. The angle between these lines was measured and called the defect angle (Fig. 1, *A*).

In a next step, maps of the bony deficits were created as described by Armitage et al[2] and Mellema et al.[9]

The respective slice was uploaded in the GNU image manipulation program (GIMP), which is freely distributed software used for photo retouching, image composition, and image authoring (www.gimp.org, V2.8.14p1). In GIMP, again, the most posterior point of the bony glenoid cavity (*B*) was identified (Fig. 1, *B*).[5] Furthermore, the most inferior point of the bony glenoid cavity (*D*) and 11 quadrants on the bony rim of the glenoid cavity were marked as described before (Fig. 1, *B*).[5] For the latter one, the depiction as shown in the work by De Wilde et al[5] was used as a jig. Next, a glenoid template was created by photographs of a standard anatomic scapular model (Scapula, Sawbones; Pacific Research Laboratories, Inc., Vashon Island, WA, USA). The photographs were imported into GIMPk and *B* and *D* were marked manually on the template.

In the following steps, the CT slice of each patient was imported, and *B* and *D* were used as landmarks to fit the CT scan onto the template (Fig. 2). Once a fit was reached, the osseous defect line was drawn using the pencil function (Fig. 3). The quadrant in which the inferior defect edge (IDE) ended was recorded. Scans depicting the inferior edge incompletely due to the layer's rotation were excluded from IDE analysis. Once the defect line was drawn, the picture was removed, and the next picture was fitted. All measuring and mapping was performed by a single orthopedic surgeon and then verified by 2 senior surgeons on the fellowship level.

For the template, a right scapula was used. Left shoulders were mirrored by 180° as described before.[2,9] To show the differences between different defect sizes, a 23% defect

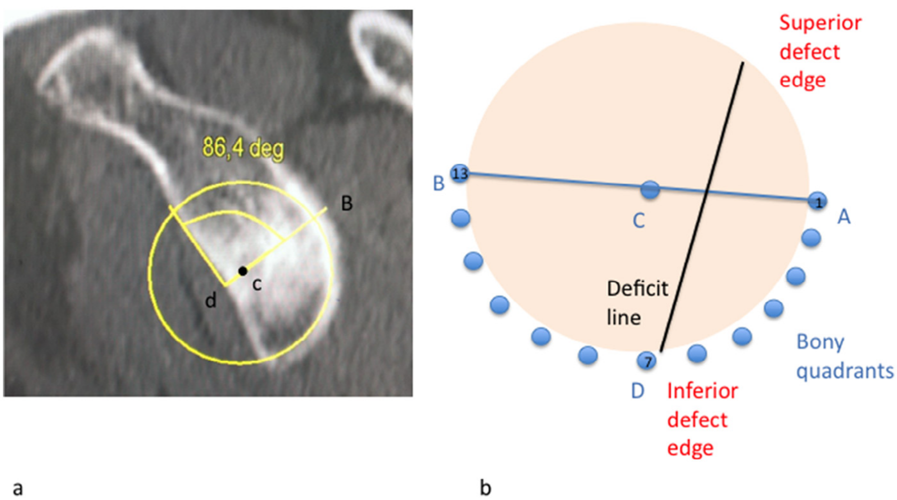

Figure 1 (**A**) Example of defect angle measurement. (**B**) Schematic demonstration of inferior defect edge measurement.