A NEW SOFTWARE SOLUTION FOR 3D AUTOMATED BONE LOSS EVALUATION IN SHOULDER INSTABILITY

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BACKGROUND

It is well established that glenoid bone loss (Bankart lesions) and humeral head bone loss (Hill–Sachs lesions) are associated with shoulder instability. Glenoid bone loss after anterior shoulder dislocation has been noted in up to 41% [1] of patients after an initial dislocation and 90% of patients with recurrent instability [2,3]. The incidence of Hill–Sachs lesion ranges from 38% to 88% and is associated with up to 100% of recurrent dislocations [4,5].

An universally accepted method to quantify glenohumeral bone loss does not exist yet and preoperative assessment of the bone defect is crucial for surgical decision making and is very often, subjective. It is now established that the current standard modality to use is computed tomography [6] and to date there are two types of calculation currently used: The linear methods [7,8] and the surface methods [9,10,11].

The linear methods usually overestimate the defect [12,13] are not accurate, as they do not consider the different concavity of the glenoid vault [15].

The surface area methods, are more reliable but still inaccurate, due to lack of precision of the best fit circle positionin [16] and a large inter and intra observer variation in the measurements of certain patients was substantial enough to affect the selection of surgical procedures probably due to subjective different skill in the calculation [16].

For all these reasons, a new software has been developed automated, accurate and rapid.

MATERIALS AND METHODS

We did a 30 cases study with glenoid bone loss (GBL) to verify the level of accuracy of area methods and the evaluation was performed using the PICO area method by three different observers.

On the other hand to overcome area methods issues a new software prototype properly built to improve calculation of GBL has been used.
All the subsequent steps have been implemented using software automation in order to reach the best GBL assessment.

Starting from CT scan in DICOM format a 3D bone structure reconstruction is obtained.

To improve rendering quality and assessment, artifact cleaning and optimized segmentation is performed (fig. 1).

Bone districts analysis and humeral subtraction allow to analyze injured glenoid and its contralateral for a good understanding of the the glenoid bone loss GBL (fig. 2).

The software performs the mirroring of the contralateral glenoid to evaluate the GBL (fig. 3). In order to simplify the comparison step, the controlateral bone district is brought near the injured bone district.

ROI (Region Of Interest) selection is performed on both glenoid districts (injured and contralateral) putting a control sphere on glenoid fossa.

Narrowing the ROI from scapula to glenoid fossa improves the next step: the superimposition.

The most important step is the superimposition of the two ROI, injured and controlateral glenoid (fig. 5).

The superimposition algorithm is optimized through several iterations of positioning.
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The glenoid bone loss artifact is reconstructed and evaluated in terms of shape, volume and best fit positioning on the injured glenoid (fig. 6).

After the evaluation the volume of the defect can be printed and exported in 3D common formats to obtain a Glenoid Bone Loss (GBL) custom made (fig. 7).

The software was validated at the ICLO lab Center.

7 cadaveric specimens, CBCT scan and a graduated glass cylinders set, were used in order to compare the volume obtained by the software.

We simulated the GBL by cutting each glenoid with chirurgical saw with random cut from 15% to 25% of GBL (fig. 8).

Fig. 5

Fig. 6

Fig. 7

Fig. 8
Throughout the CBCT scan DICOM before and after the cut the software assessed the GBL in terms of volume, shape and positioning (fig. 9, 10).

To validate the volume obtained by the software we compared each GBL volume calculation with the volume of the real bone defect obtained with the water displacement method (fig. 11).

**RESULTS**

As regards the study on surface method accuracy carried out on the 30 cases, we found that there was not a good concordance between observers because the results were different and the Linear Concordance Coefficient was low (Table 1).

![Fig. 9](image)

![Fig. 10](image)

![Fig. 11](image)

**Table 1**

As regards of software results, the validation session has revealed us a very good and accurate GBL volume assessment.

The evidence comes from the low bias: about 10% of the measurement, as showed in table 2.
**CONCLUSIONS**

In conclusion to date, the current techniques to measure GBL, either linear or surface methods are inaccurate and dependent on different observer skills, due to the difficult and slow applications of the calculation systems for the orthopedic scientific community. We found out that overcome subjectivity is possible via software automation. The software prototype we implemented has a high automation level; humeral subtraction and ROI selection steps can be done with a click, all other steps are automated.

The software validation session showed us the accuracy obtained in the GBL assessment in terms of volume, shape and positioning. Results are very encouraging. This is the first software that allows anyone, regardless his abilities, to obtain, in real time, an objective and accurate assessment of the GBL. We are upgrading this software with a new module, to obtain an automated 3D Pico to assess the percentage of the GBL. In the early future we are planning to upgrade the same software with another module, for the assessment of the Hill Sachs lesion to understand really, when bipolar lesions lead to risk of engagement and plan the correct surgical procedure.
REFERENCES


