Determining On/Off Track Lesions In Glenohumeral Dislocation Using MPR CT Is Easier And More Reproducible Than Using 3D-CT.

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## Mandatory faculty disclosure

<table>
<thead>
<tr>
<th>Faculty Name</th>
<th>Financial Conflicts</th>
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<tbody>
<tr>
<td>Laura Mulleneers, MD</td>
<td>I have no financial conflicts to disclose</td>
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<td>Hannah Van Rompaey</td>
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<td>Baïdir Haloui</td>
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<tr>
<td>Nicole Pouliart, MD, PhD</td>
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</table>
Background

Glenoid track:
= useful to predict the risk of recurrence of dislocation (engagement), in the presence of Hill-Sachs and/or Bony Bankart lesion
= the zone of contact from the glenoid on the posterolateral surface of the humeral head, that is created when the arm is abducted with a constant external rotation.
= 83% glenoid width – width of the bone defect

Fig.1: a. bony defect; b. glenoid track; c. 83% glenoid width

Fig.2: A Hill-Sachs lesion (green circle) staying within the glenoid track, is considered on-track.
Fig.3: A Hill-Sachs lesion (red circle) extending more medially than this zone of contact, will hook or engage the glenoid in functional position. This off-track lesion is at risk for recurrence of dislocation
Fig.4.: To date, 3D-reconstructed images are used to assess the glenoid track preoperatively.

**A.** Glenoid width = diameter of the best fit circle (red circle)
Bony defect = distance between bone and circle on horizontal diameter (d)
Glenoid track = 83% glenoid width – width of the bone defect (83%-d)

**B.** HSI = the distance from the rotator-cuff footprint to the most medial margin of the lesion (green line)

HSI < glenoid track = on-track.
HSI > glenoid track = off-track
Background

BUT…

Are 3D-reconstructed images really what we need???

→ special and expensive software are needed to get 3D reconstructions
→ many different software exist → alters the reproducibility of the measurements.
→ Obtain 3D-images takes time → difficult to use it in daily practice.
→ To get a correctly 3D reconstructed and oriented image several steps are required → reliability decreases
→ Orientation is relative to the observer → lack of a clear and standardized description of the CT image that should be created
→ The use of arthro-CT-scans are not allowed → However, contrast is useful to show lesions to the labrum and glenohumeral ligaments.

SO…

A cheaper, standardized method that takes less time to assess and allowing the use of intra-articular contrast seems required.
Materials and Methods

- Using a standard CT with **multiplanar reconstructions (MPR)**, we developed a method to assess the glenoid track. The MPR-method was compared to the 3D reconstructed (3DR) images.

- **52 CT-scans**, matching the inclusion/exclusion criteria, were analysed in Horos.

- **Glenoid width, bony defect, Hill Sachs interval** (HSI) were measured on MPR & 3DR images.

- Repetition of the measurements: twice by the same observer + measured by two other observers (unaware of the results of the others)

**Statistics**

- Data analyse: Linear Mixed Model
  - MPR vs. 3D
  - Intraobserver and interobserver reliability
Materials and Methods

Fig. 5: Measurement of the glenoid width and bony defect on 3D. The glenoid was oriented to obtain an *en face* view.

A: Glenoid width without bone loss
B: Glenoid width with bone loss
C: Bone loss measurement

Fig. 6: Assessment of the HSI on 3D (yellow line):

1. A posterior view of the humeral head was obtained
2. The rotator cuff footprint was drawn (blue line)
3. HSI = the distance measured between the rotator cuff footprint and the most medial margin of the defect, on a line perpendicular to the footprint (yellow line)
Fig. 7: In MPRs, the axes in one plane correspond to the projections of the 2 other planes. When one alters the axes in any of the three planes, the two corresponding planes are adjusted.

A view, comparable with the *en face* view of the glenoid on 3D was obtained in the sagittal plane (A.). To assess this view, the axis was placed parallel to the inferior articular surface of the glenoid in the axial and coronal planes (Fig. B & C. yellow line). On the sagittal plane, the axis was placed along the longitudinal axis of the glenoid (Fig. A, blue line).

Fig. 8.: Assessment of the glenoid width and bony defect on MPR:
- Glenoid width = diameter best fit circle
- Bony defect = distance between the remnant margin of the anterior glenoid and the anterior margin of the circle
Materials and Methods

Fig. 9: Orientation of the humerus on MPR. The axes were placed parallel with the midline of the humeral shaft on sagittal (A) and coronal (C) reconstructions. On axial (B), the axes were placed at an angle of 45° with a line going through the bicipital groove, with the centre of a circle drawn around the humeral head as vertex.

Fig. 10: Assessment of the HSI (green line) on the axial plane (A). The blue point on coronal (B) represents the projection of the mouse cursor from axial (green arrow in fig. A). In this figure, the projection of the mouse cursor in the axial plane reaches to the rotator cuff footprint on coronal plane (red line on coronal). The RC-footprint was drawn between point 1 and 2. So, the HSI reaches from the green arrow to the medial margin of the Hill-Sachs lesion on the axial plane. A third point (Point 3) was also drawn on the coronal plane and its coordinates were used to calculate the RC angle, used to calculate the real HSI with the following formula:

\[ HSI = \cos(\text{RC angle}) \times \text{measured HSI} \]
Results – glenoid width and bony defect

Fig. 11

<table>
<thead>
<tr>
<th>Measurement method</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPR (2D)</td>
<td>0.040897</td>
<td>0.007706</td>
<td>0.000</td>
<td>0.025421 − 0.056374</td>
</tr>
<tr>
<td>3D</td>
<td>0</td>
<td>0</td>
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Fig. 11: An effect of 0.04 cm was observed when using MPR instead of 3D to assess the glenoid width. Although statistically significant, this small difference is probably not meaningful from a clinical perspective.

Fig. 12

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MPR (2D)</th>
<th>3D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observer 1, 1st measurement</td>
<td>Estimate</td>
<td>Sig.</td>
</tr>
<tr>
<td></td>
<td>-0.12635</td>
<td>0.439</td>
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<tr>
<td></td>
<td>±0.016279</td>
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<tr>
<td>Observer 2</td>
<td>-0.109074</td>
<td>0.000</td>
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<tr>
<td></td>
<td>±0.016395</td>
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<tr>
<td>Observer 3</td>
<td>0.022495</td>
<td>0.172</td>
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<tr>
<td></td>
<td>±0.016395</td>
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<tr>
<td>Observer 1, 2nd measurement</td>
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</table>

Fig. 12: Intra- and interobserver effect on the measurement of the glenoid width for MPR and 3DR separately. The second measurement of observer 1 was taken as reference. So, the first line represents the intra-observer variability and the 2nd and 3rd line the interobserver reliability. 3D reconstructions seem to offer no added value in validity and reliability of evaluating the glenoid bone.

Fig. 13

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<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPR (2D)</td>
<td>0.013499</td>
<td>0.008457</td>
<td>0.117</td>
<td>0.030475 − 0.03477</td>
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<tr>
<td>3D</td>
<td>0</td>
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Fig. 13: No significant effect was observed of the used measurement method on the measurements of the glenoidal bony defect.
Results – Hill-Sachs Interval

**Fig.14**: The difference between MPR measurements and 3D measurements of the Hill-Sachs Interval was limited to 0.07 cm, which is less than the error margin of 0.1 cm.

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<thead>
<tr>
<th>Measurement method</th>
<th>Estimate (cm)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
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</thead>
<tbody>
<tr>
<td>MPR, 1st measurement</td>
<td>-.073987</td>
<td>.013416</td>
<td>,000</td>
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<td>3D, 2nd measurement</td>
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**Fig.15**: Intra- and interobserver effect for the measurements of the HSI for MPR and 3DR separately. The second measurement of observer 1 was taken as reference. So, the first line represents the intra-observer variability and the 2nd and 3rd line the interobserver reliability. The effect of the observer on the HSI measurements on 3D could be as large as 0.19 cm. In contrast, the effect of the observers, for either MPR-measurement was not statistically significant, varying between 0.007 cm and 0.03 cm.

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<th>Sig.</th>
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<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observer 1, 1st measurement</td>
<td>-.030658</td>
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<td>,114</td>
<td>±.051346</td>
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<tr>
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<td>±.019446</td>
<td>.697</td>
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<tr>
<td>Observer 3</td>
<td>-.027056</td>
<td>±.019446</td>
<td>.166</td>
<td>±.197238</td>
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<tr>
<td>Observer 1, 2nd measurement</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
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Conclusion

- The use of multiplanar reconstructions is at least as accurate as 3D reconstructions for the assessment of the glenoid track and Hill-Sachs interval.

- Allowing a standardised, reproducible description of the orientation and measurement method, the MPR seems to have a better intra- and interobserver variation than 3D images.

- Since MPR is more time efficient and less costly than 3D and because CTA can be used, MPR should be considered as a valid alternative for daily practice.
References