Editorial Commentary: Methodology of Measuring Bone Loss in Recurrent Shoulder Instability Surgery: Traditional Computed Tomography Scan and Magnetic Resonance Imaging Do Not Tell the Full Story

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Abstract: When measuring bone loss in recurrent shoulder instability, both computed tomography (CT) scan and magnetic resonance imaging (MRI) are accurate using the circle method. However, measurement of on- versus off-track lesions can be inconsistent, and measuring Hill-Sachs lesions on MRI relative to an extrapolated rotator cuff attachment is difficult. In the end, determination of on- versus off-track treatment is quite difficult, and for this determination, differences between CT scan and MRI may be clinically imperceptible. Thus, for now, we, and we believe, other surgeons will continue to stick with the circle technique when determining individual patient treatment for recurrent shoulder instability.

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In their study, "Does Bone Loss Imaging Modality, Measurement Methodology, and Inter-Observer Reliability Alter Treatment in Glenohumeral Instability?" Chalmers, Christensen, O'Neill, and Tashjian[1] performed a retrospective review over a 5-year period of patients who underwent surgical treatment for glenohumeral instability. Fifty-three patients had both a magnetic resonance imaging (MRI) and a computed tomography (CT) scan obtained within 1 year of each other before an anterior stabilization procedure. If patients had scans more than 1 year apart, they were excluded from this study. In the methodology, after the scans were obtained and reviewed retrospectively, the authors downloaded the CT and MRI scans in DICOM format and uploaded them into a freely available viewing software called OsiriX. In this manner, the sagittal sequence was reoriented on the plane of the glenoid as defined by the superior pole and inferior pole and most posterior osseous point of the glenoid.[2] After this, the sagittal image was saved and the axial sequence, which was based on this reformatted sagittal sequence, was reviewed. This was the axial sequence in which the Hill-Sachs lesion was the widest was saved.

After the sagittal reformatting and then saving the sagittal image on the glenoid face and the axial image where the Hill-Sachs was widest, these being the 2-dimensional images, the measurements were then made on each of these scans. These measurements assessed the en face glenoid and used a best-fit circle to measure glenoid width on the sagittal view and then on the Hill-Sachs view, which was defined as the 1 axial image that displayed the largest Hill-Sachs, the posteroanterior aspect of the Hill-Sachs and on-track/off-track measures were performed.[3-6] Linear percent bone loss was also calculated on these axial scans. An on-track/off-track determination was made using standard and prior well-referenced techniques.[7-10]

Overall, the authors are to be congratulated for using multiple observers for the determination of these

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measurements. The average surface area from the circle method on CT scan was 18.4% and on MRI was 16.8%. The standard deviation was noted as 7.5% and 7.1%, respectively. The average linear measure for percent glenoid bone loss on CT scan demonstrated 23.5% versus MRI of 20.5%. The overall differences were small regardless, 1.6% of MRI versus CT scan on the circle method versus on the linear percent, glenoid bone loss was 2.9%. These were statistically significant, but it does beg the question of whether this is truly clinically significant given that it was only 1.6% different on the area and only 2.9% different on the linear. In the average patient, approximately 5% bone loss equals anywhere from 1.4 to 1.7 mm, so we are talking a fraction of a millimeter here, a 0.2- to 0.4-mm difference for area findings and up to 0.8- to 0.9-mm difference on linear percent bone loss. The on-track/off-track determinations were also very similar, but the MRI designations for on-track lesions was higher than the CT scan on-track by about 7%, with an overall reasonable agreement between observers. The percent agreement for only 2 observers was between 75% and 91%, indicating some of our continued challenges with measuring the accuracy of on-track versus off-track.[11-15]

Overall, the authors felt the CT led to larger measurements of percent glenoid bone loss than MRI with more shoulders, approximately 7% total, being considered to demonstrate off-track bone loss. If solely looking at the on- versus off-track measures, which did have some level of interobserver unreliability, the authors believed they would alter the treatment from 25% to 34%.

The authors overall concluded that there were significant differences of bone loss measured between imaging modality measurements and observers that may lead to treatment in up to 34% of cases. The authors' methodology should be congratulated in that:

1. They have corrected the sagittal oblique sequence to be superoinferior with the axial images in the plane of the long axis of the glenoid.
2. The circle method first introduced by Sugaya et al.,[16] although not 100% accurate, is likely the best-accepted model among shoulder instability surgeons.
3. The Hill-Sachs cuff determination and on- versus off-track remains a challenge and is highlighted here in their study with a low of 75% agreement in 1 of the track measurements.

The importance of this study is that it highlights the necessity of looking at the 3 parameters outlined previously. Once this is done well, we get a much more accurate sagittal oblique without doing a 3-dimensional CT scan or even 3-dimensional MRI imaging, which is now starting to emerge.[5] To better characterize this, the authors could have looked at a gold standard being the 3-dimensional CT scan, which could have been reformatted from the axial images done well in the sagittal plane. It is well known that the 2-dimensional reformats on CT scan (and MRI as well) do not show bone loss accurately unless they are reformatted; then, it is probably close to what we obtain on 3-dimensional sequences with the humeral head digitally subtracted.[16-20]

When looking at the study closely, however, there are only very small differences in bone loss from the circle method. This is measured very well by the authors in square millimeters; when this is compared with MRI versus CT scan in a well-formatted sagittal oblique, the differences are really not that large and in a linear method at 3% is probably less than 1 mm of difference. In the area method, it is probably in the 6- to 10-mm^2 range difference, given their small differences of 1.6% to 2.9%. Although these were found to be statistically significant, certainly given their tight and nearly equivalent standard deviations, it seems as though the authors have demonstrated that both CT and MRI scans are accurate if you use the circle method. Moreover, this study truly highlights the inconsistencies in measuring on- and off-track lesions resulting from inaccuracies, and, let's be honest, the difficulty of measuring Hill-Sachs lesions on MRI relative to the extrapolated rotator cuff attachment. This is 1 of the issues we have had to deal with when we extrapolated the original study of Itoi et al.,[10] who did this in an open cadaveric model. These have since been extrapolated to MRI and CT findings.[5,11-14,21-23]

Thus, we believe that the authors have actually demonstrated that the CT and MRI scans are in very close agreement when this is reformatted using the circle technique of Sugaya et al.[16] They demonstrated at best a 3% difference on the linear measure, but we do know that this is only perhaps a 1-mm difference given the 3% difference, and the percent glenoid bone loss on the circle method is probably an imperceptible difference clinically, even though this was found to be statistically significant. These findings may not be clinically relevant, and we believe that a finding that you have an average of 17 mm versus 18 mm of glenoid bone loss is not going to drastically alter treatment patterns. However, the authors are congratulated for highlighting what is believed to be the best part of this paper, the differences in MRI and CT scans and challenges with interobserver reliability in determining on-and off-track treatment.

With additional work, we believe that the authors can help in better defining how we measure on- and off-track lesions of the shoulder given their patient cohort and current limitations and would encourage them to do so to help us all better understand how to measure and define patients. In the meantime, we, and we believe others, will continue to stick with the circle technique, possibly adding in on- and off-track if clinically appropriate and easy to measure. We do know the accuracy of the circle is an important aspect of our overall treatment algorithm. Clearly, methodology matters.

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