Glenoid Bone Loss:
You Can Measure This!

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Disclosures – none

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Bankart Lesion

The "essential" lesion for anterior shoulder instability

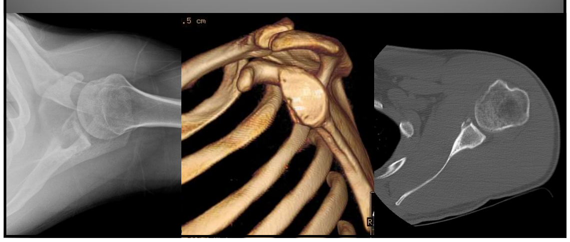
Recurrent Shoulder Instability

Failure rates after open and arthroscopic surgery are noted to be **as high as 20-30%**

What are the MAJOR risk factors?

Glenoid Bone Loss

Recurrent instability rates approach **90 to 100%** in the setting of **anterior glenoid bone loss**



Glenoid Bone Loss – Key #1

Understand the *type* of bone loss

Acute fracture

Chronic attritional loss

Glenoid Bone Loss – Key #2

Understand how to *MEASURE* bone loss

Because…

The amount of bone loss impacts surgical decision-making → *critical size defect*

Critical Size Defect

- % GBL associated with recurrent instability when treated with soft tissue stabilization alone
  - 25% width (Lo and Burkhart)
  - 20% length (Itoi)
  - 13.5% width (Shaha, Tokish)

Back to Key #2 – How to measure GBL

- Many different techniques
- >100 publications
- Most common methods → **CT**, **MRI**, **Arthroscopy**

Quantification (in part) determines treatment!

Methods must be accurate, valid, and reproducible

CT measurement methods → MANY

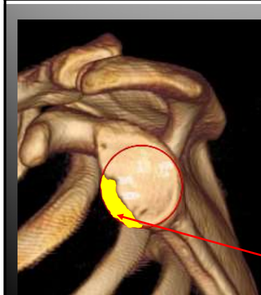
TABLE III Computed Tomography Methods* for Quantification of Glenoid Bone Loss[8,22-24,26,47]

Quantification Method	Description
Surface area method[22]	➤ Three-dimensional computed tomography image of glenoid with humeral head subtraction is obtained ➤ Best-fit circle is drawn on inferior 2/3 of pear-shaped glenoid ➤ Osseous deficiency is measured directly on circle with use of digital means
Superimposed circle method[8]	➤ Best-fit circle centered at bare-spot approximation is drawn on injured glenoid and contralateral, uninjured glenoid ➤ Glenoid circle on normal shoulder is superimposed on injured-shoulder circle ➤ Preinjury size and amount of bone loss are calculated
Pico method[47]	➤ Best-fit circle is drawn on inferior portion of contralateral, uninjured glenoid with use of MPR (multiplanar reconstruction) software, and its surface area (A) is digitally calculated ➤ Circle is superimposed onto injured glenoid, and surface area of defect (D) is calculated ➤ Percent bone loss = D/A × 100%
AP distance from bare area method[26]	➤ Bare area is approximated on computed tomography with use of intersecting lines ➤ Distances are measured from bare area to anterior edge of osseous lesion (A) and from bare area to posterior aspect of glenoid rim (B) ➤ Percent bone loss = ([B − A]/2B) × 100%
Bankart length measurement[24]	➤ Best-fit circle with radius (R) drawn on inferior 2/3 of glenoid ➤ Length of osseous lesion (x) is measured ➤ If x > R, dislocation resistance is ≤70% of that of an intact joint
Ratio method[23]	➤ Best-fit circle with radius (R) is drawn on inferior 2/3 of injured glenoid ➤ Distance is measured from center of circle to anterior edge of osseous lesion (d) ➤ Percentage bone loss found with use of ratio d/R and specialized graph expressing percent bone loss as function of (d) and (R)

*A three-dimensional computed tomography scan with digital subtraction of the humeral head is best for accurate quantification.

Provencher et al 2010

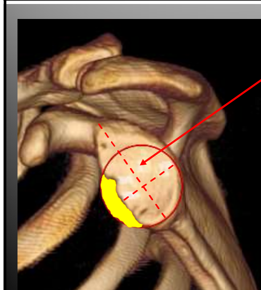
CT basics



- Most current techniques utilize 3D reconstructions with an *en face* view of glenoid
- Model the inferior 2/3rds of glenoid as a best fit circle (Sugaya et al)

Approximation of GBL (Huysmans et al)

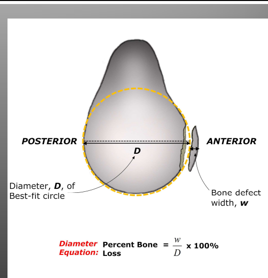
More CT basics



- GBL typically occurs along a line parallel to long axis of glenoid, not 45 degrees (Provencher 2008)
- Position of patient/scapula in the CT scanner may impact measurements (Gross 2016, Frank 2018)
- Some measurement techniques may over-estimate GBL, impacting surgical decision-making (Bhatia 2015)

CT → Diameter Method

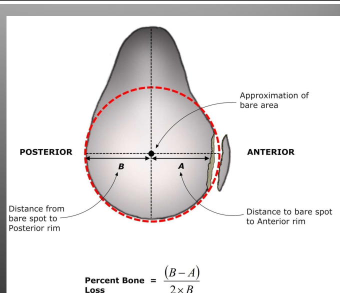
- Glenoid *en face* view
- Defined by defect width (w) and best fit circle diameter (D)
- **% GBL** = w/D x 100%



Sugaya et al., 2005

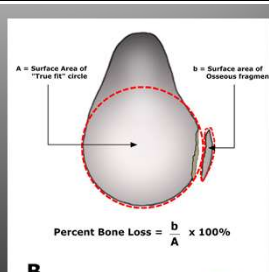
CT → Glenoid Rim Distances

- Utilizes location of bare area to estimate GBL
- Burkhart 2002
- Sugaya 2005
- Lo 2004



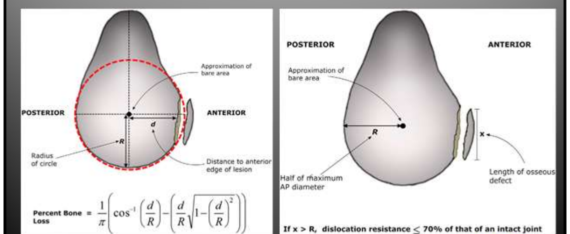
CT → Surface Area Method

- Digitally measure surface area of "true fit" perfect circle and of the osseous defect
- Osseous fragment MUST be present for this to work



Sugaya et al., 2003

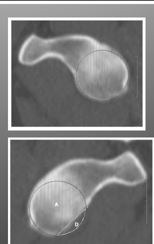
CT → Ratio Method (Barchilon)



$$\text{Percent Bone Loss} = \frac{1}{\pi}\left(\cos^{-1}\left(\frac{d}{R}\right) - \left(\frac{d}{R}\sqrt{1-\left(\frac{d}{R}\right)^2}\right)\right)$$

CT → Pico Method (Baudi *et al* 2005)

- 2D CT scan
- Uses opposite (healthy) shoulder with an identical perfect circle to determine the amount of GBL
- Modified technique uses the intact posterior-inferior margin of inner glenoid to determine pre-injury glenoid circle



What about MRI

- Ideal method → most patients already have the MRI
- How does it compare to CT?

Quantification of a glenoid defect with three-dimensional computed tomography and magnetic resonance imaging: A cadaveric study
Pol E. Huijsmans, MD,[a] Pieter S. Haen,[b] Martin Kidd, PhD,[c] Wouter J. Dhert, MD, PhD,[b] Victor P. M. van der Hulst, MD, PhD,[d] and W. Jaap Willems, MD, PhD,[a] *Amsterdam and Utrecht, The Netherlands; and Stellenbosch, South Africa*

Skeletal Radiol (2014) 43:213–218
DOI 10.1007/s00256-013-1774-5
SCIENTIFIC ARTICLE
Use of 3D MR reconstructions in the evaluation of glenoid bone loss: a clinical study
Soterios Gyftopoulos · Luis S. Beltran · Avner Yemin · Eric Strauss · Robert Meislin · Laith Jazrawi · Michael P. Recht

Quantifying Glenoid Bone Loss in Anterior Shoulder Instability
Reliability and Accuracy of 2-Dimensional and 3-Dimensional Computed Tomography Measurement Techniques
Aaron J. Bois,* MD, MSc, FRCSC, Stephen D. Fening,†‡§ PhD, Josh Polster,‖ MD, Morgan H. Jones,*¶ MD, MPH, and Anthony Miniaci,*¶ MD, FRCSC
Investigation performed at Cleveland Clinic, Cleveland, Ohio

Skeletal Radiol (2013) 42:347–352
DOI 10.1007/s00256-012-1489-z
SCIENTIFIC ARTICLE
3DMR osseous reconstructions of the shoulder using a gradient-echo based two-point Dixon reconstruction: a feasibility study
Soterios Gyftopoulos · Avner Yemin · Thomas Mulholland · Michael Bloom · Pippa Storey · Christian Geppert · Michael P. Recht

Radiol med (2013) 118:1335–1343
DOI 10.1007/s11547-013-0927-x
MUSCULOSKELETAL RADIOLOGY
RADIOLOGIA MUSCOLO-SCHELETRICA
MRI can assess glenoid bone loss after shoulder luxation: inter- and intra-individual comparison with CT
La risonanza magnetica può quantificare il danno osseo glenoideo in seguito a lussazione della spalla: valutazione comparativa inter- e intra-individuale con la TC
Alessandro Stecco[1] · Elena Guenzi[2] · Teresa Cascone[1] · Francesco Fabbiano[2] · Paolo Fornara[3] · Paolo Oronzo[1] · Federico Alberto Grassi[3] · Gregorio Cecchi[4] · Mario Caniggia[4] · Marco Brambilla[2] · Alessandro Carriero[1]

Diagnostic Accuracy of MRI in the Measurement of Glenoid Bone Loss
Soterios Gyftopoulos1, Saqib Hasan2, Jenny Bencardino1, Jason Mayo1, Samir Nayyar2, James Babb1 and Laith Jazrawi2

What about MRI

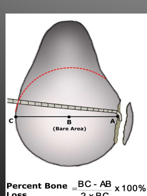
Three-Dimensional Magnetic Resonance Imaging Quantification of Glenoid Bone Loss Is Equivalent to 3-Dimensional Computed Tomography Quantification: Cadaveric Study

Adam B. Yanke, M.D., Jason J. Shin, M.D., Ian Pearson, B.S., Bernard R. Bach Jr., M.D., Anthony A. Romeo, M.D., Brian J. Cole, M.D., M.B.A., and Nikhil N. Verma, M.D.

- **Both 1.5T and 3T 3D MR correlated with 3D CT measures of bone loss**
- ***Use of 3D MRI may reduce or obviate the need for CT scans, decreasing cost and radiation exposure***

Arthroscopic Bare Area Method

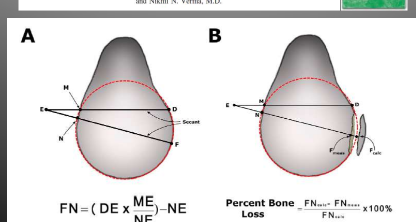
- Use calibrated probe to measure distances from the bare area (Burkhart 2002)
- Glenoid inferior circle roughly ~28mm in diameter



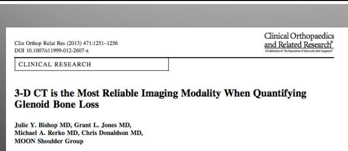
Arthroscopic Secant Method

A New Arthroscopic Technique to Determine Anterior-Inferior Glenoid Bone Loss: Validation of the Secant Chord Theory in a Cadaveric Model

Alvin J. Detterline, M.D., CDR Matthew T. Provencher, M.D., MC, USN, Neil Ghodadra, M.D., Bernard R. Bach Jr., M.D., Anthony A. Romeo, M.D., and Nikhil N. Verma, M.D.



Well, what is the best method?


Clin Orthop Relat Res (2013) 471:1251–1256
DOI 10.1007/s11999-012-2607-x

Clinical Orthopaedics and Related Research®

CLINICAL RESEARCH

3-D CT is the Most Reliable Imaging Modality When Quantifying Glenoid Bone Loss

Julie Y. Bishop MD, Grant L. Jones MD,
Michael A. Rerko MD, Chris Donaldson MD,
MOON Shoulder Group

Cadaver study comparing XR, CT, 3D CT, and MRI

- **3D CT** → most reliable modality for predicting bone loss
- Standard CT → 2nd most reliable and reproducible

Well, what is the best method?


J Shoulder Elbow Surg (2013) 22, 528-534

ELSEVIER

Journal of Shoulder and Elbow Surgery
www.elsevier.com/locate/ymse

Comparison of various imaging techniques to quantify glenoid bone loss in shoulder instability

Michael A. Rerko, MD[a], Xueliang Pan, PhD[b], Chris Donaldson, MD[c], Grant L. Jones, MD[a], Julie Y. Bishop, MD[a,*]

Cadaver study comparing XR, CT, 3D CT, and MRI

- **3D CT** → most accurate modality for predicting bone loss
- Standard CT → 2nd most accurate

Take Home Points

- **3D CT or MRI are both acceptable**
- Some methods may over or under-estimate GBL
- **KEY POINT → Measuring GBL does not take into account location of the bone loss (ie, glenoid track), bipolar bone loss (ie, Hill Sachs lesion), or chronicity of bone loss**
- **KEY POINT → While % GBL impacts decision-making, there remains no consensus on the "critical size defect" and we must take into account patient-specific factors**


Thank You
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