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# How bone quality may influence intraoperative and early postoperative problems after angular stable open reduction–internal fixation of proximal humeral fractures

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**Background:** With the introduction of the deltoid tuberosity index (DTI), a simple radiographic tool has become available to measure bone mineral density of the proximal humerus. The aim of this study was to assess the influence of local bone mineral density on the early failure rate after angular stable open reduction–internal fixation of proximal humeral fractures (PHFs).

**Methods:** We retrospectively followed up all patients treated with angular stable implants for PHFs from 2007 to 2014. The fractures were classified according to Neer, and the DTI, metaphyseal head extension (MHE), medial hinge displacement, and quality of reduction were assessed. Failures were defined as head screw cutouts.

**Results:** The study included 146 patients (mean age, 66 years; range, 20–94 years). The mean follow-up period was 11 months (range, 3–94 months). Of the fractures, 91% were classified as 2- or 3-part fractures and 9% as 4-part fractures. The mean DTI was 1.44 (range, 1.19–2.11), and the mean MHE was 12 mm (range, 0–48 mm). The reduction result was at least acceptable in 80% of fractures. Screw cutouts were found in 23%. The DTI and MHE were the most significant preoperative predictors for the reduction result. The DTI ( $P = .036$ ) and age ( $P = .02$ ) were independent preoperative factors, and a good reduction ( $P = .001$ ) was the only intraoperative factor influencing cutout.

**Discussion:** This study proves that good bone quality and a long MHE are helpful for the reduction. Furthermore, good bone quality, a younger age, and a good reduction prevent later cutout. We conclude that local bone quality is a relevant factor in the treatment plan for PHFs.

**Level of evidence:** Level IV; Case Series; Treatment Study

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**Keywords:** Proximal humeral fracture; BMD; deltoid tuberosity index; DTI; cutout; bone quality; failure rate

The institutional review board approved this study. All patients gave informed consent to use and publish their anonymized data.

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The role of local bone quality in the treatment and outcome of proximal humeral fractures is still controversial.<sup>13,14</sup> However, more and more reports are appearing in the literature showing that either general osteoporosis<sup>12</sup> or low bone quality, measured directly at the proximal humerus,<sup>3,20</sup> has a direct impact on the complication rate after angular stable open reduction–internal fixation (ORIF) of proximal humeral fractures. In our clinical practice, we have seen simple fracture types failing postoperatively after a relatively short time even though the reduction and fixation were good (Fig. 1). Thus we agree with many authors that the assessment of bone quality should be part of the decision-making process for the operative treatment of proximal humeral fractures.<sup>3,8,12,20,21,23,26</sup>

However, one of the limiting factors in assessing local bone quality is the lack of validated measurement methods. The dual-energy x-ray absorptiometry method is still the gold standard to diagnose osteoporosis, but there is not yet a defined threshold value for the proximal humerus. To assess local bone quality, peripheral quantitative computed tomography (pQCT) has become more important,<sup>13,15,26</sup> but its availability is limited

and the analysis can be complicated. Radiographic assessment of local bone quality has therefore become the focus of many studies in recent years.<sup>6,7,20,26,30</sup> We defined the deltoid tuberosity index (DTI), which is a simple tool to measure local bone quality directly proximal to the deltoid tuberosity on the anteroposterior (AP) fracture radiograph (Fig. 2). This structure usually is not affected by the fracture and is well outlined on the AP fracture radiograph because of the internally rotated relieving posture of the arm. In an initial study, we found a strong correlation ( $r = 0.80$ ,  $P < .001$ ) between the DTI and the bone mineral density (BMD) of the humeral head (measured with pQCT).<sup>26</sup> Furthermore, we validated the use of this index for proximal humeral fractures and found that the DTI has a high intraobserver and interobserver reliability and a good clinical applicability for AP fracture radiographs.

The aim of this study was to assess the influence of local bone quality, measured with the DTI, on the operative treatment and on the early outcome after angular stable ORIF of proximal humeral fractures.



**Figure 1** The *top row* shows a Neer 2-part fracture with a deltoid tuberosity index of 1.29: measurement of metaphyseal head extension (degree symbol, 0 mm in this case) (*left*), postoperative reduction result (*middle*), and varus collapse with subsequent cutout after 2 months (*right*). The *bottom row* shows a Neer 2-part fracture with a deltoid tuberosity index of 1.65: measurement of displacement of medial hinge (asterisk, >2 mm in this case) (*left*), postoperative reduction result (*middle*), and radiographic follow-up after 6 months (*right*).

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