The influence of local bone quality on fracture pattern in proximal humerus fractures

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ABSTRACT

Introduction: Bone mineral density and fracture morphology are widely discussed and relevant factors when considering the different treatment options for proximal humerus fractures. It was the aim of this study to investigate the influence of local bone quality on fracture patterns of the Neer classification as well as on fracture impaction angle in these injuries.

Materials and methods: All acute, isolated and non-pathological proximal humerus fractures admitted to our emergency department were included. The fractures were classified according to Neer and the humeral head impaction angle was measured. Local bone quality was assessed using the Deltoid Tuberosity Index (DTI). The distribution between DTI and fracture pattern was analysed.

Results: 191 proximal humerus fractures were included (61 men, mean age 59 years; 130 women, mean age 69.5). 77 fractures (40%) were classified as one-part, 72 (38%) were two-part, 24 (13%) were three- and four-part and 18 (9%) were fracture dislocations. 30 fractures (16%) were varus impacted, whereas 45 fractures (24%) were classified as valgus impacted. The mean DTI was 1.48. Valgus impaction significantly correlated with good bone quality (DTI $\geq$ 1.4; p = 0.047) whereas no such statistical significance was found for the Neer fracture types.

Discussion: We found that valgus impaction significantly depended on good bone quality. However, neither varus impaction nor any of the Neer fracture types correlated with bone quality. We conclude that the better bone quality of valgus impacted fractures may be a reason for their historically benign amenability to ORIF. On the other hand, good local bone quality does not prevent fracture comminution.

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Introduction

Proximal humerus fractures are among the most common injuries in the human skeletal system [1]. Because of the increase in aging population, the relevance of these injuries is expected to grow over the next decades. Even 45 years after the first classification and recommendations in fracture treatment by C. Neer [2,3], decision making remains difficult. Fracture type, dislocation and age are considered main predictors for functional outcome. However, osteoporosis, functional demand of the patient, vascular impairment and the implants used are accounted to be relevant in treatment decision making as well [4–6]. Since proximal humerus fractures are considered fragility fractures, the role of general and local bone mineral density is gaining more and more interest in the literature [4,7,8].

To assess and quantify the local bone quality of the proximal humerus, we previously developed the deltoid tuberosity index (DTI). The DTI is directly measured proximal to the deltoid tuberosity on the anteroposterior X-ray, and in a prior study was found to have a strong correlation with the bone mineral density of the humeral head as measured with pQCT [9].

It was the aim of this study to investigate if specific fracture patterns of the Neer classification as well as fracture impaction angle are associated with local bone mineral density. The literature is lacking papers on this topic. To assess the influence of local bone quality on the fracture complexity and morphology, we questioned the following Hypothesis:

H1. One-part fractures are the least complex fractures and thus have better bone quality compared to two-, three ore four-part fractures.

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H2. Bone quality influences the complexity of one-part fractures, in terms of the number of segments.

H3. Three- and four-part fractures are more complex and might have lower bone quality compared to one- or two-part fractures.

H4. Varus or valgus impaction of the head fragment correlates with local bone quality.

Materials and methods

We included in the study all acute, isolated and non-pathological proximal humerus fractures admitted at our emergency department from January 2014 to August 2015.

Two board certified orthopaedic trauma surgeons independently and retrospectively classified the fractures according to Neer using the fracture radiographs (anteroposterior- and outlet view) or, if available, CT-scans. In case of diverging opinions, a consensus reading was applied. Every possible Neer-fracture-configuration was allocated a code (Fig. 1). Furthermore, the impaction angle of the head fragment was measured on the anteroposterior fracture radiograph using the head inclination angle (CCD) as described by Hertel in his antropomethric study on the proximal humerus [10] and varus- or valgus-impacted fractures were identified (Fig. 2a–b). Since the mean CCD ranges between 132° and 142° we considered fragments to be varus impacted with a $CCD < 130°$ and valgus impacted with a $CCD > 140°$.

Local bone quality was assessed on the anteroposterior fracture X-ray using the deltoid tuberosity index (DTI) [9]. The DTI is measured directly proximal to the deltoid tuberosity where the outer cortical borders become parallel. At this level, the ratio between the outer cortical and the inner endosteal diameter is calculated (Fig. 3a–b). We suggested a DTI value of <1.4 to predict poor bone stock (bone mineral density <80 mg/cm^3 in pQCT) of the
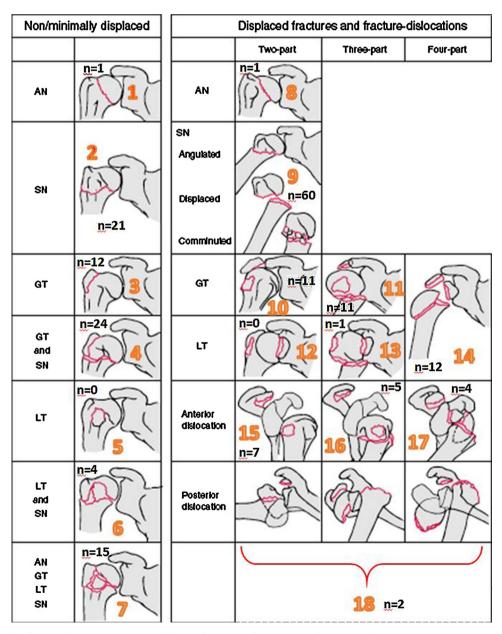

Fig. 1. All fractures were classified according to Neer. Every possible Neer-fracture-configuration was allocated a code. AN (Anatomical Neck); SN (Surgical Neck); GT (Greater Tuberosity); LT (Lesser Tuberosity).