Biomechanics Pressure Analysis of Proximal Humeral Fracture Malunion

Mario H Lobao, MD; Manesha Lankachandra, MD; Roshan T Melvani, MD; Pooyan Abbasi, MSME; Brent G Parks, MSC; Anand M Murthi, MD

Department of Orthopedics and Sports Medicine, Shoulder and Elbow Service – MedStar Union Memorial Hospital, Baltimore, Maryland

Objectives

Deformity considered acceptable for proximal humeral fractures has been subject to continuous debate. Neer's original paper tolerated up to 45º angulation. Recent studies have suggested deformities over 30º have unfavorable prognosis for post-traumatic arthritis.

The purpose of this study was to investigate the effects of humeral neck malunion on glenohumeral contact pressures.

Methods

Fifteen cadaveric shoulders (74.4y) were tested in a custom motorized frame (Fig 1). Shoulder was cycled from 0 to 60º at 1rpm. Muscle loading simulated active shoulder elevation: 80N on deltoid, 20N on each cuff muscles.

Contact pressures were measured using digital sensors (Tekscan) inserted into the glenoid and subacromial space (Fig 2).

A custom humerus plate with two perpendicular serial hinges simulated 15º, 30º and 45º malunion deformities in sagital and coronal planes (Fig 3).

Test conditions: intact, simple varus, valgus, antecurvatum and retrocurvatum, and combined deformities.

ANOVA/Fisher-LSD performed for each independent variable at P<0.05.

Fig 1

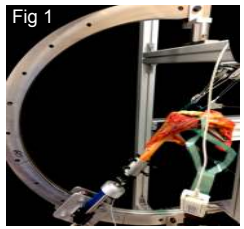


Fig 2

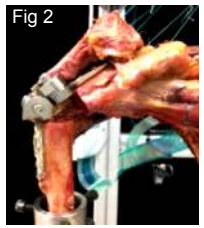
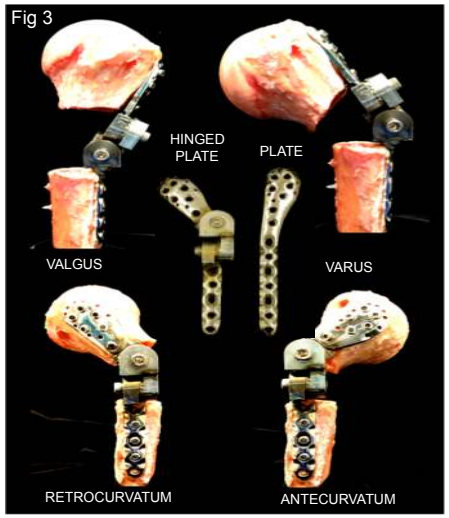
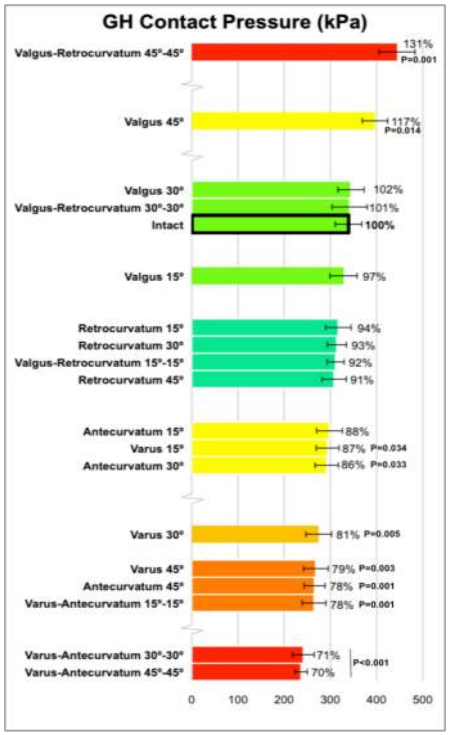
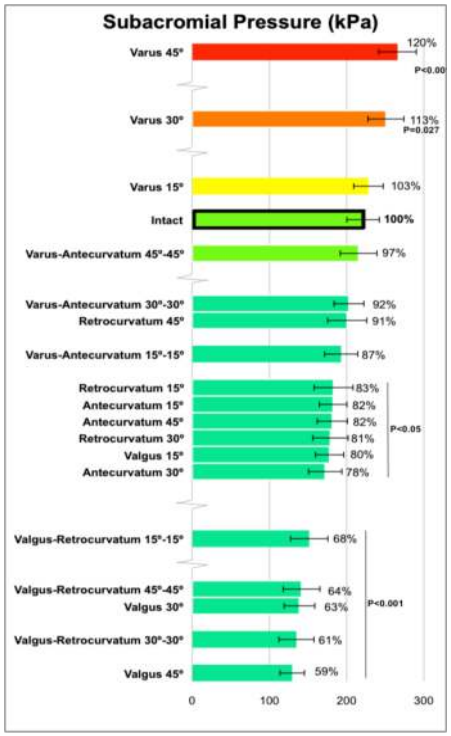


Fig 3







Results

Glenohumeral contact pressures were 13% (P=0.034) lower with varus 15º, 19% (P=0.005) with varus 30º, and 21% (P=0.003) with varus 45º malunion compared to intact.

Valgus 45º deformity increased glenohumeral pressure 17% (P=0.014) over intact. Valgus 30º increased 2%, and valgus 15º decreased 3%.

Antecurvatum 30º and 45º decreased contact pressures 14% (P=0.033) and 22% (P=0.001) respectively.

Retrocurvatum deformities kept glenohumeral pressures within 10% of intact values.

Biplanar valgus-retrocurvatum 45º-45º deformity increased glenohumeral pressure 31% (P=0.001), while varus-antecurvatum 45º-45º and 30º-30º decreased pressures 30% (P<0.001) and 29% (P<0.001) respectively.

All deformities except varus decreased subacromial pressures. Varus 30º increased subacromial pressure 13% (P=0.027), and varus 45º increased 20% (P<0.001) over intact.

Varus 30º deformity presented a loss of 5.8 ± 1.0º (P<0.001) in abduction arch, and varus 45º lost 15.4 ± 1.7º (P<0.001). No other malunion incurred in loss of range of motion.

Conclusions

Even small varus 15º deformity resulted in decreased glenohumeral contact pressure beyond 10% of the cut-off range of a normal shoulder, suggesting that patients may not tolerate it because of long-term infra-physiologic glenohumeral pressures result in degenerative changes due to inadequate nutrition to the cartilage.

Single plane deformities up to 30º in valgus and up to 45º retrocurvatum, and biplanar valgus-retrocurvatum up to 30º-30º presented glenohumeral pressures within a ± 10% range of an intact shoulder, indicating that these deformities may be better tolerated than varus, antecurvatum and varus-antecurvatum malunions.