Role of Regional Bone Mineral Density on Ankle Fracture Pattern

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Introduction & Literature Review

Ankle fractures are a common injury treated by foot and ankle surgeons, frequently classified on plain film radiographs using the Lauge-Hansen system (1). In each stage, malleolar fracture or ligamentous rupture is sustained. However, it is unclear what factors account for this difference. We suspect bone mineral density (BMD) is a contributing factor. Decreased BMD is a known risk factor for fragility fractures, often hip, wrist and spine fractures in the elderly (2). The correlation between BMD and ankle fractures has not been well documented. To measure BMD, dual x-ray absorptiometry (DXA) is considered the gold standard but is expensive and time consuming. Using pre-operative computed tomography (CT), however, we can assess BMD in Hounsfield units (HU) (3). Warner et al showed that HU from the injured versus contralateral extremity had nearly perfect agreement, supporting this method to accurately measure BMD for fractures. They also found BMD on the injured extremity significantly correlated with lumbar, hip, and total BMD based on DXA within 3 months of injury (4). The purpose of this study was to determine BMD as a contributing factor in the number of fractured malleoli in adult ankle fractures.

Methodology

108 patients with operatively repaired ankle fractures from July 2017 to August 2019 were included. Exclusion criteria included: 1) age > 18, 2) pre-operative CT available and 3) underwent open reduction internal fixation (ORIF). Exposure criteria were: 1) no pre-operative CT, 2) chronic injuries, 3) revisional ORIF, and 4) open injuries. Retrospectively chart review was performed to collect age, sex, past medical history, smoking history, charactersistics of fracture pattern, and regional bone density. Preoperative radiographs and CT were reviewed. Fractures were classified via the Lauge-Hansen system (1). In each stage, preoperative planning (7).

Results

Of the 108 subjects, 39 were male, 69 were female. Average age was 50.7 years. Average BMI was 30.3 ± 22.5 kg/m2; tobacco use in 26 (24.1%), and diabetes mellitus in 18 (16.7%) patients. Average BMD was 233.8 ± 233.5. When divided by malleolar involvement there were 8 unimalleolar, 33 bimalleolar, and 67 trimalleolar fractures. The majority of fractures were supination-external rotation injuries (n=60). There was an inverse relationship between BMD and malleolar involvement (p = 0.04) for unimalleolar (mean 264 HU), bimalleolar (mean 251 HU), and trimalleolar (mean 220 HU) fractures. An inverse relationship was found between age and regional BMD (p<0.001). No relationship was found between tobacco use and BMD (p=0.94) or between BMD and Lauge-Hansen classification (p = 0.13).

Discussion

Rotational mechanism of injury has been described with the Lauge-Hansen system. Injury pattern includes malleolar or ligamentous injury. We investigated a correlation between BMD and fracture severity. The influence CTs have on surgical treatment of ankle fractures has been discussed by numerous authors (5,6). We had more trimalleolar versus unimalleolar fractures, likely because CT images were obtained for surgical planning (7).

We believe that fracture classification is based on mechanism and incidence of injury while the presence of malleolar versus ligamentous injury is strongly influenced by regional BMD. Hey et al found that in femoral neck fractures, the fracture traversed areas with lowest BMD, suggesting a higher proclivity for fracture in those regions (8). While CT is not an alternative to DXA in evaluation of global BMD, CT should be used to evaluate regional BMD preoperatively. This can provide insight to bone quality before reaching the operating room. In multiple studies, locking plate fixation for bimalleolar fractures has increased fixation strength in osteoporotic bone compared with nonlocking fixation (9,10,11). Tingart et al found that pullout strength of cancellous screws in the humeral head was significantly lower in areas of decreased BMD (12). This can help reduce, or justify, the cost of internal fixation based on BMD.

There are inherent limitations with retrospective analyses. This cohort of patients may not be representative of populations in other centers or areas, which may limit generalizability of results. There is possible interrater variability in BMD measurements.

In conclusion, our results show a significant correlation between decreased BMD and number of malleolar fractures. This supports the suspicion that decreased BMD plays a role in the occurrence of malleolar versus ligamentous injury. CT is routinely ordered for surgical planning of complex fractures but can also be used to assess BMD. This can be used for fixation considerations, peroperative risks, and system treatment to optimize bone metabolism.

References