Comminuted Intra-Articular Distal Tibia Fracture Fixation Using Computer Surgical Planning and 3D Prototyping Techniques

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Purpose: Comminuted intra-articular distal tibia fractures are often associated with significant fragment displacement and severe soft-tissue injury. Surgeons use plain film radiographs and CT scans (2-dimensional [2D] or 3D) to determine fracture pattern and displacement; however, it can still be difficult to identify the location of all fracture fragments. The purpose of this study was to determine if a 3D-printed plastic prototype of injury could enhance the surgeon's preoperative (preop) plan and impact clinical outcomes. The hypothesis was that the 3D-printed plastic prototype can enhance a surgeon's preop plan.

Methods: Pilot Study: Patients aged 18 to 75 years with isolated, distal tibia fractures (AO/OTA 43C) were randomized to group 1: enhanced preop planning (3D-printed plastic prototype and routine imaging) or group 2: preop planning using routine imaging alone (3D-reconstructed CT and radiographs). Models of the injury were imported into a computer-aided design software (Unigraphics NX8; Siemens PLM) and converted into plastic prototypes (V-Flash 3D printer; 3D System Corp; 1:1.2 ratio). Surgeons (blinded to assignment) completed an initial preop plan for all patients using routine imaging alone. Afterward, surgeons were provided a 3D plastic prototype of injury (group 1) and repeated the preop surgical plan. 3D-printed plastic prototypes were used intraoperatively for visualization as needed. Final surgical details were collected for comparison. Percentage of agreement and surgeon confidence was calculated (9 categories: approach, sequence, anatomic contoured plate tibia, anatomic contoured plate fibula, small fragment plate, mini-fragment plate, mini vs extensile, fibula fixation, bone graft).

Results: 20 total participants had mean age 44 years, 60% male, 60% fall from height, 60% closed injury (1 infection withdrawn). Group 1 (enhanced n = 11) averaged 84.8% level of agreement between the initial surgical plan without versus with the 3D prototype, and had an increase in confidence from 80.5% to 84.6% (confidence in group 2 was 78.1%, n = 8). Agreement with preop plan and final operative events was 76% in group 1 and 71.4% in group 2. In one case, after review of the 3D-printed prototype, the surgeon changed the surgical approach and ultimately eliminated a third stage of surgery. Clinical outcomes did not differ between groups after 1 year postoperatively.

Conclusion: This study assessed the impact of 3D-printed plastic prototype models in the surgical plan of complex distal tibia fractures. Although the percentage of agreement with the preop plan to final operative events was not very high, the 3D-printed plastic prototype increased the surgeon's confidence with the preop plan. In 1 case, a return surgery was eliminated. Further studies need to explore the potential cost benefit of a 3D printing program.