First Clinical Results of a Novel Technique in the Reduction of Long Bone Fractures Using a Solely 3D-Printed External Fixator in Multiply Injured Patients: A Matched-Pair Analysis

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Purpose: The reduction of long bone fractures can be challenging using standard techniques, such as intramedullary nailing (IMN), especially considering axis, length, and torsion. A femoral maltorsion of more than 10° leads to a reduction in quality of life and can contribute to the development of degenerative joint diseases. The challenge increases notably when a patient has multiple injuries and needs initial treatment with an external fixator according to the damage control principles. Due to comorbidity, the interval to definitive treatment may be up to several weeks, leading to muscle shortening and bone healing in malposition. Longer operation times, higher intraoperative radiation doses, and an increased likelihood for an open reduction are some of the associated problems. Our goal was to investigate whether a 3-dimensional (3D)-printed external fixator could improve the accuracy of reduction and reduce the risk for revision surgery compared to a control group.

Methods: We developed a novel technique to perform closed reduction of long bone fractures. A CT scan of the fractured bone follows the initial damage control surgery with the application of an ordinary external fixator. A reduction aid is built uniquely for each patient through additive manufacturing. It uses the preexisting Schanz screws to bring the fracture fragments into an optimal alignment, which is predetermined, according to virtual fracture reduction. The 3D-printed fracture reduction aid can be used as a tool in the operating theater or applied in the ICU for severely injured patients not suitable for further operations. We treated 14 patients using the technique described above. Postoperative CT data of the lower extremity were available in all cases. Also, all patients had weight-bearing radiographs of their mechanical axis 6 months after definitive treatment. A control group was created by matching patients of the same fracture type (according to AO), operated on by the same surgeon, within the same year of surgery. We detected statistically significant differences using the Mann-Whitney U test.

Results: The mean age of the patients is 22.34 ± 6.14 years, and 70% are male. 12 patients have a femoral fracture, and 2, a tibial fracture. The mean ISS is 38. The median for maltorsion in the control group is 14°. The intervention group is at 2.2° ($P = 0.002$). The median of the length difference between the femora after conventional IMN is 7 mm, and it is 2.4 mm after the 3D-printed navigated IMN ($P = 0.001$). Postoperative varus deformity is less distinct in the 3D group than in the control group (0.85° vs 1.9°, $P = 0.109$).

Conclusion: This case series demonstrates that the use of 3D-printed external fixators can assist in fracture reduction and leads to a better fracture alignment. More extensive studies are needed to prove the benefit of this newly invented method.