Bone filler and adhesive at the same time: Biomechanical analysis in a porcine fracture model.

Stefanie Hoelscher-Doht[1], Nicola Zufall[1], Martin C. Jordan[1,2], Rainer H. Meffert[1], Uwe Gbureck [3], Lea Huels[1]

[1]Department for Trauma, Hand, Plastic and Reconstructive Surgery, University Hospital of Würzburg, Germany
[2]Department of Orthopedic, Trauma and Rehabilitative Medicine, University Medicine Greifswald, Germany
[3]Department for Functional Materials in Medicine and Dentistry, University Hospital of Würzburg, Germany
Email: hoelscher_s@ukw.de

Summary

A revolutionizing new bone cement with sticky properties enables the use of the gluing cement as an adhesive to temporary fix small bone fragments together and, at the same time, as a bone filler for defects. Biomechanically, the sticky bone filler provides a high stability in a clinically relevant test set-up.

Introduction

Bone defects are a major challenge regarding their treatment. Especially, in metaphyseal fractures, bone defects remain after reduction of depressed fracture fragments like in tibial head fractures [1]. Experimental magnesium phosphate cements with sticky properties [2] could be used for filling up the defect, and at the same time, be used as bone adhesive for temporary fixation of fracture fragments. So, the aim of this study was to analyze the provided stability of the new glueing cement in a clinically appropriate test model.

Methods

Lateral split-depression fractures of the proximal tibia were generated in 27 porcine specimens (Fig. 1a). The bones were then randomized into 3 groups (n=9). In group A, a new operative technique was applied by reducing the fracture using a newly formulated magnesium phosphate cement (MgP cement) and then the stabilization by plate osteosynthesis was performed (Fig. 1b). In the other two groups, plate osteosynthesis was performed first, as in the current standard operative procedure, followed by the injection of a bone graft substitute through a gap in the fracture area of the tibia, group B with MgP cement, group C with a standard hydroxyapatite cement. The displacement of the lateral plateau, stiffness and maximum load were determined in dynamic and static loading tests in a material testing machine (ZwickRoell Z020) (Fig. 1c+d).

Figure 1: Lateral split-depression fractures in porcine specimens were generated (1a) and reduced in group A with the sticky bone cement (1b). All specimens were biomechanically tested for displacement, maximum load and stiffness in dynamic and static loading tests (1c+d).

Results and Discussion

The results present a comparable stability for all groups with no significant differences in all forms of displacement, with group A demonstrating the lowest values for displacement (Fig. 2). Maximum load was highest for group C (group B; C [$p = 0.04$]; group A; C [$p < 0.01$]), however considering normalized maximum load no significant difference between the three groups can be found.

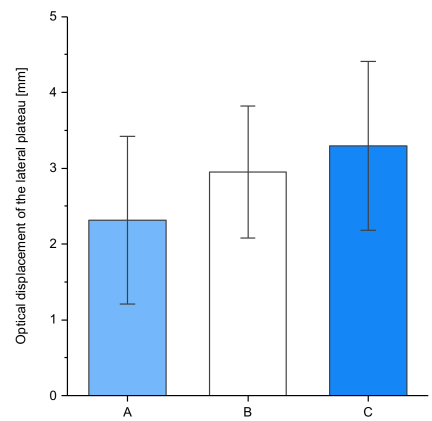

Figure 2: Group A (using the cement for the new operative technique) revealed the lowest displacement of the lateral tibial plateau, even though the significance level was not reached.

Conclusions

The adhesive and drillable magnesium phosphate cement proves to be a versatile solution featuring a new surgical method in which the fracture is anatomically reduced using only the cement. Furthermore, with this new technique, the cement demonstrates comparable, if not slightly superior, biomechanical stability in the porcine tibial split depression fracture model compared to the current standard of surgical treatment.

Acknowledgments

The authors thank the German Research Foundation (DFG), research grant number DFG HO 5851/2-1, for funding this project.

References

[1] Hofmann A et al. (2020) *J Bone Joint Surg Am*, **3**: 179-93.
[2] Bruckner T et al. (2019) *Materials*, 12(23).