Bone evaluation of stem cell treatments in jaw bone

SE Hieber[1], C Jaquiery[2], C Kunz[2], B Ilgenstein[1], B Müller[1]

[1]*Biomaterials Science Center, University of Basel, Allschwil, Switzerland.* [2]*Department of Cranomaxillofacial Surgery, University Hospital Basel, Basel, Switzerland*

INTRODUCTION: Distraction osteogenesis proved to be powerful for correcting craniofacial deformities, especially in younger patients. The simultaneous expansion of the bone and the surrounding soft tissue promises an enhancement of further growth and stability[1]. The time effort is a main drawback of the procedure resulting in high costs and the risk of disturbed healing during the consolidation period. Therefore, the current challenges are the increase of the distraction rate and the acceleration of osseous consolidation while preserving the bone quality.

METHODS: The effect of additional stem cell supply was studied on 4 nude rats (CR) in a pilot study. Human stem cells were injected at the beginning of the protocol into two rats. Two rats served as control. After a latency period of five days, linear distraction was performed at a regular rate of 0.5 mm/day up to a distance of 6 mm. The specimens were harvested 40 days after distraction before full consolidation[2].

The three-dimensional (3D) imaging of the extracted jaws was carried out post mortem using nanotom®s (GE, Wunstorf, Germany). The nanotom is a 180-kV nanofocus scanner, that accommodated the entire jaw with a maximal length of 16 mm (pixel size 6.9 µm). After decalcification, the rat mandibles were scanned at the beamline BW 2 (HASYLAB, DESY, Hamburg, Germany). Synchrotron radiation- based µCT (SRµCT) measurements in absorption contrast mode were performed using a photon energy of 14 keV with a pixel size of 2.5 µm. VG Studio Max 2.1 (Volume Graphics, Heidelberg, Germany) served for the 3D representations and their slices.

RESULTS: Fig. 1 shows the results of the CT scans of the mandibles before de-calcification. The 3D representations and the 2D slices above show the differences in the mineralization with stem cells injection (left) and without one (right). Complete osseous bridging of the distraction gap is observed after stem cell treatment, whereas osseous healing remains incomplete otherwise. The SRµCT measurements confirms the findings and enables the comparison to histological slices.

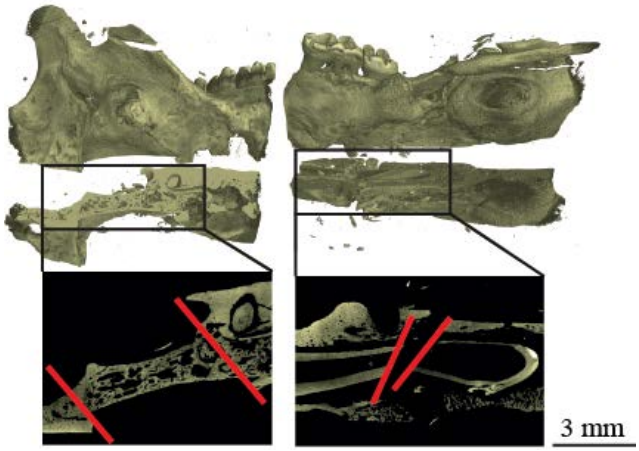

Fig. 1: The quantity of the newly formed bone can be evaluated in the 3D representations and virtual cuts of the mandibles after regular distraction with injection of stem cells (left) and without injecting stem cells (right) scanned by the nanotom® s before de-calcification.

DISCUSSION & CONCLUSIONS: The combination of high-resolution µCT with dedicated histology permits the optimization of distraction osteogenesis incorporating stem cells before starting the distraction. The CT scans revealed the enhancement of bone formation with complete bridging of the interzone, whereas in the control animal an unmineralized interzone remained. CT-analysis is a non-destructive tool to identify the mineralization complementary to histological slices and to determine regions and cutting directions for histology.

REFERENCES: [1] C. Kunz et al. (2005) *Distraction osteogenesis of the canine mandible – The impact of acute callus manipulation on vascularization and early bone formation* J Oral Maxillofac Surg 63: 93-102. [2] B. Ilgenstein et al. (2012) *Combined micro computed tomography and histology study of bone augmentation and distraction osteogenesis* Proc SPIE 85060: 85060M.

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