Bonestone® for posterolateral fusion

The CABMM studies the use of synthetic bone substitute Bonestone® for posterolateral fusion

Posterolateral fusions (PLF) in humans are often the last resort to stop pain and further neurological deterioration in chronic cases of degenerative disk disease. Whether instrumented or non-instrumented techniques should be used is often a matter of debate, whereas the use of bone grafts to accelerate fusion is the common standard. The gold standard for grafts is autografts that are commonly taken from the pelvic crest, a painful procedure for the patient with long-term morbidity and sometimes complications. Frozen or lyophilised bone grafts can also be applied; however, safety precautions for disease transmissions have to be taken into account. Therefore, the use of synthetic, off-the-shelf grafts is an attractive alternative.

For standardised testing of PLF with or without grafts, sheep are a viable alternative to non-human primates, which for ethical reasons are difficult to use in experimental animal models. An earlier study performed in our laboratory (MSRU)[1] showed that the outcomes of instrumented PLF in sheep using transpedicular screws and rods with or without autografts are similar in long-term results at 12 months after surgery. However, differences were noted between three and seven months, where the autograft augmented PLF clearly showed an advantage and better midterm fusion was achieved. Differences were especially highlighted at five months.

Fig. 1 (Top) and Fig. 2 (Bottom) Left side, prior to screw and rod explantation spinal fusion, new bone formation at 16 weeks

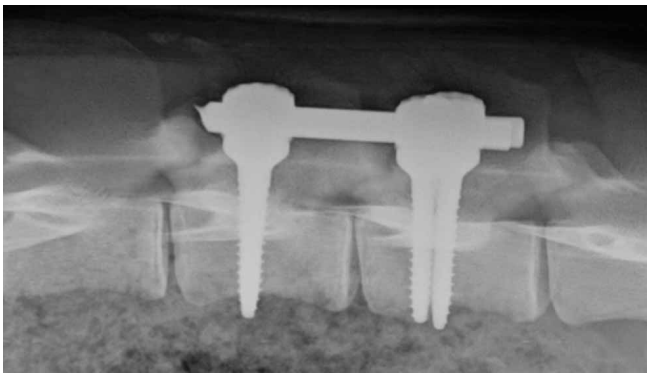

Fig. 3 Conventional radiograph latero-lateral projection; eight weeks post-op

Bonestone®[2] is a bone substitute that was deliberately developed for PLF grafting procedures. The material is a proprietary, next-generation, magnesium and calcium-based biocompatible, bioresorbable bone substitute that comes in the form of 1-3mm granule. It is used as sole augmentation without any further stimuli (like bone marrow aspirate, autografts, etc.).

In our preliminary study, three experimental female Swiss Alpine sheep were used (two to three years of age, mean 72.3kg weight), where an instrumented PLF of the L3/L4 was performed. The animal experiments were conducted according to the Swiss laws of animal protection and welfare and were authorised by the cantonal authorities (Licence No. 128/2013). Superficial decortication of the articular facets and the transverse processes at the fusion site was performed, and Bonestone placed at either lateral side of the fused vertebrae. Computer tomography (CT) at 11 or 12 weeks and at the time of sacrifice at 16, 19 and 23

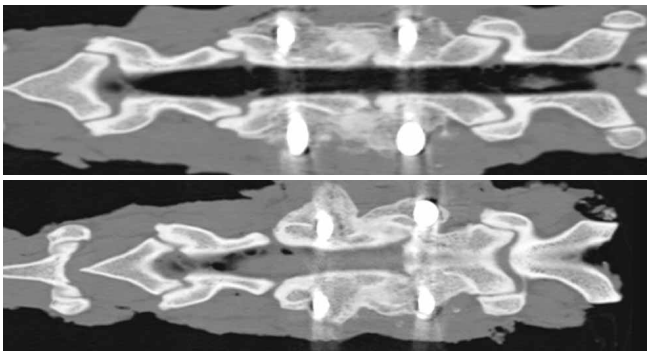

Fig. 4 (Top) Dorsoventral projection at articular processes, heterotrophic bone formation and facet arthrodesis between L3-4 at 19 weeks and Fig. 5 (Bottom) Dorsoventral projection at articular processes, heterotrophic bone formation and facet arthrodesis between L3-4 at 23 weeks

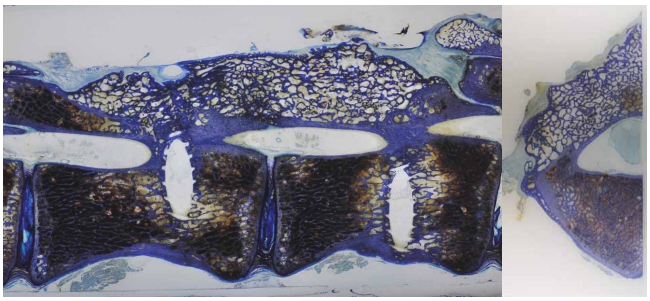

Fig. 6a and Fig. 6b Histology sections: 19 weeks

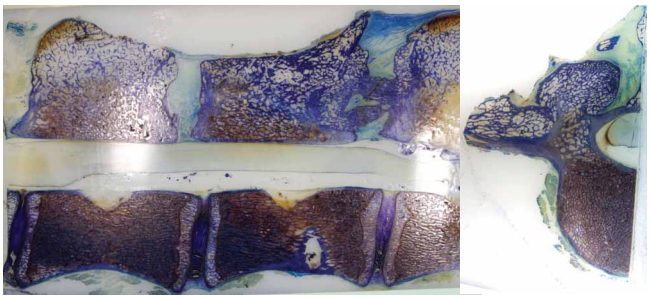

Fig. 7a and Fig. 7b Histology sections: 23 weeks

weeks, when one sheep was slaughtered at each time point. Fluorescence dyes were injected at six weeks post-op (calcein green; 5mg/kg BW) and at 12 weeks post-op (xylenol orange; 90mg/kg BW) to document new bone deposition and remodelling at the early stages.

Apart from CT evaluation, macroscopic examination and tests for fusion were performed at the time of sacrifice. Histological examination of the fusion sites was conducted on non-decalcified bone specimens prepared as ground sections (400-500µm) that were surface stained with toluidine blue. In addition, conventional radiographs and microradiographs (faxitron) showed the calcification status of the fusion sites. The incorporation of the fluorescence dyes was visualised in native sections.

The results revealed compact new bone formation was visible between the vertebrae in all three sheep macroscopically, on CT, radiographs and histological sections. New bone formation could already be noticed on radiographs at eight weeks of age and was fully confirmed with CTs in all three sheep at 11 weeks post-surgery. Differences between the three time points were only in the consolidation and maturity of the bone, respectively, the remodelling of the original cortex of the transverse processes,

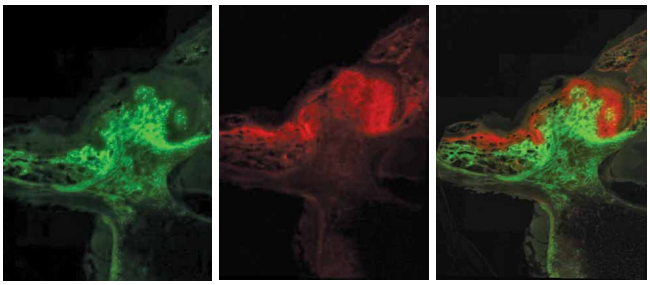

Fig. 8a, Fig. 8b and Fig. 8c Transverse fluorescence sections of the left side of the spine, calcein green injection at six weeks (green colour), xylenol orange (red colour) at 12 weeks post-surgery. Green and red colour indicates calcium deposition and new bone formation at these time points, each colour is shown separate and in combination

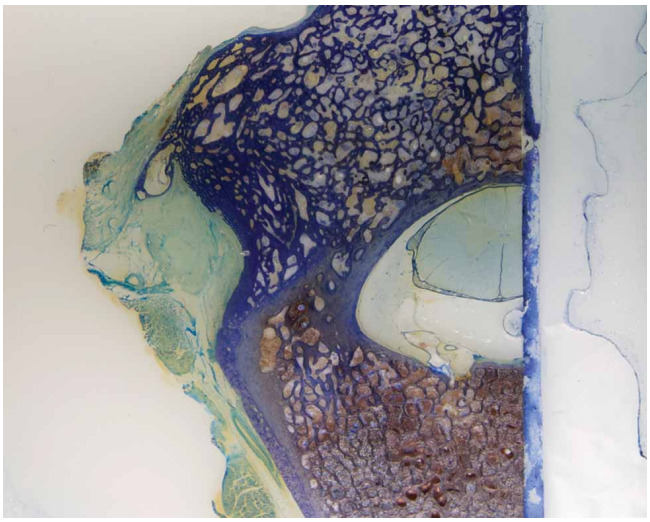

Fig. 9 A close-up and transverse histology section of the fused vertebra shows complete fusion and remodelling at 24 weeks after surgery

respectively, articular facets. Bonestone accelerated the fusion process considerably for at least three months and additionally showed a much more compact, consolidated and larger fusion area compared to our earlier studies in sheep using the same surgical technique with autografts.

The histology images included in this article show the heterotrophic bone formation, facet arthrodesis and bony bridging across the joint, and thickening of the lamina (heterotrophic bone formation and facet arthrodesis).

1 Bernadette Linsbichler: Posterolaterale Fusion im Schafmodell: PTH1-34-Knochenersatzstoffe versus Positiv – und Negativkontrolle (doctorate thesis, VSF, University of Zurich, accepted, July 2009).

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