FEASIBILITY OF A BIORESORBABLE MOLDING MESH IN REVISION HIP SURGERY

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INTRODUCTION
Revision surgery is of increasing importance in orthopaedic practice due to the increase of primary cases and the rising life expectancy of mankind. A major problem in revision hip surgery is the loss of bone stock. To reconstruct these defects, impacted morselized allografts are used with good results. This technique strongly depends on an adequate mechanical support of the graft. Therefore, metal support devices (meshes) are used as a mould for the graft. Metal meshes function well in terms of mechanical support and clinical results, but also have serious disadvantages, like stress shielding and eclipsing the bone remodeling process on radiographs. Also, an extra foreign body is implanted, with negative consequences in case of infection or re-revision.

A number of biodegradable polymer devices have become available as a viable alternative to metal implants, among which a trepolymer of Poly L-Lactic Acid (PLLA), Poly D-Lactic Acid (PDLA), and Poly Glycolic Acid (PGA). These polymers have shown good biocompatibility, and are already used in diverse medical fields.

Molding meshes, used in impact bone grafting procedures, loose their function after remodeling of the bone graft is completed. Consequently, they have the potential to be made of a biodegradable material. The aim of this study was therefore to assess the surgical and mechanical suitability of biodegradable molding meshes allocated in the reconstruction of bone defects during impaction grafting revision surgery.

MATERIALS AND METHODS
Six femora were harvested from three human donors. An osteotomy was performed 1.5 cm proximal from the trochanter minor. Then, all cancellous bone was removed from the femoral canal, mimicking a revision case. A calcar defect of 5 by 5 cm was created. The biodegradable meshes (Stryker Howmedica Osteonics), made of a PLLA-PDLA-PGA co-polymer at a ratio of 85:5:10, and sized 55 x 55 x 0.8 mm, were bent to match the contours of the calcar defect and attached to the bone with cerclage wires. Standard X-change revision instruments (Stryker Howmedica Osteonics) were used to perform the operation.

After the impaction procedure was finished, Exeter stems were cemented in the new bone bed.

After surgery, the femora were placed in a hydraulic material testing device (Instron 8872, Instron Corporation, USA), with the center of the femoral head positioned above the center of the knee joint. The femora were then loaded under a compressive sinusoidal force (400-800 N, 400-1200 N, 400-2000 N) for 10,000 cycles at each load. The load was applied via a flat element, allowing for horizontal shift.

A custom made four-point bending device was developed to assess maximum load bearing capacity of six plain meshes. The crosshead load was increased in steps of average 4.8 N, resulting in a bending moment of 26.4 Nmm/step.

During the surgical procedure, as well as during the mechanical loading and the four-point bending, two unidirectional strain gages (Hottinger Baldwin Messtechnik, Germany) were attached to each mesh. By means of these strain gages, the local deformation (in µm/m) in the meshes was recorded during all tests. The measurement frequency was 9600 Hz. A finite element model of the strain distributing over the meshes during the surgical procedure, mechanical loading, and in the four-point bending device, was used to determine the positions where maximum deformation was to be expected. At those positions the strains gages were attached to the meshes.

RESULTS
All meshes could easily be molded to the contour of the defects. After the surgical procedure, no macroscopic damage was seen at any of the meshes. Maximum deformation during the surgical procedure was 4369 µm/m, and an almost identical maximum deformation of 4368 µm/m was recorded during mechanical loading of the femora.

During the surgical procedure, as well as during mechanical loading, both positive and negative deformation was measured by the strain gages. Average positive deformation in the meshes during the surgical procedure was 2696 µm/m, and average negative deformation was -2007 µm/m. During the mechanical loading run with the highest compressive load (400-2000 N), the average positive deformation in the meshes was 2359 µm/m. Average negative deformation was -366 µm/m.

During the four-point bending test the meshes showed to be flexible. At a crosshead load of 30 N or more, the bulging of the meshes was the restrictive factor for increasing the load further. At that point the average deformation already exceeded 19,000 µm/m. Even at these high deformations, none of the meshes failed. All meshes returned to their original form when the load was decreased to zero.

DISCUSSION
In this study the deformation of a biodegradable mesh during impacted bone grafting and post-operative mechanical loading is compared with the deformation measured in a non-destructive four-point bending test. All meshes survived the surgical procedure and post-operative mechanical loading. The maximum deformation of the meshes was a factor four lower than the maximum deformation in the four-point bending test. During the impaction procedure and mechanical loading negative deformations were measured. This can be explained by interaction of aligning parts of the meshes, resulting in negative deformation when surrounding parts bulge out.

The maximum compressive load of 2000 N (more than two times body weight) during post-operative mechanical loading is considerable for a femur that has just been operated on. In vivo measurements of Bergman [1] indicate that, 11 - 31 moths postoperative, the average patient loads his hip joint about 250% body weight during walking and stair climbing. It can thus be assumed that the forces applied in his study are in the same range as in vivo. Nevertheless, the maximum deformation in the meshes did not come near the maximum deformation they can withstand.

We showed that the deformation in a biodegradable mesh during and after a revision procedure, does not come near the deformation they can resist. Therefore, we conclude that from a biomechanical point of view, these meshes are suitable for the use in impaction grafting revision surgery.

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