Novel silk protein barrier membranes for guided bone regeneration

Introduction

Different types of bioresorbable and nonresorbable membranes have been widely used for guided tissue regeneration (GTR). An alternative could be the use of silk-membranes (Fig. 1) which exhibit several advantages. During manufacturing individual modifications are possible, no infection risks are associated with their implantation and the mechanical characteristics are excellent [1-8]. In this study we examined the binding of hydroxyapatite (HA) and beta-Triacilcium phosphate (β-TCP) to silk-membranes and evaluated the effects on cell proliferation in vitro and effects on facilitating bone formation and defect repair during guided bone regeneration.

Material and Methods

Two calvarial bone defects of 12 mm (Fig. 2) in diameter were created in each of a total of 38 rabbits and four different types of membranes, (silk-, hydroxyapatite-modified silk-, β-TCP-modified silk- and collagen-) were implanted to cover one of the two defects in each animal. Hematology, body weight and general health were monitored throughout the 10 weeks of the study period which were all within the normal range for all animals and histologic analysis did not show any adverse reactions in any of the defect sites, demonstrating good biocompatibility of all silk protein membranes.

Results

After 10 weeks, the collagen membrane was resorbed in all cases, while the silk membrane was still visible in 1/5 (20%) and the hydroxyapatite-silk membrane in 4/5 (80%) cases in the micro-CT scans. β-TCP-modified silk membranes remained visible in all cases. Histomorphometric evaluation revealed significantly higher (p<0.002) new bone ingrowth into defects covered with β-TCP modified silk membranes compared to new bone ingrowth into defects without any barrier membrane cover. The highest rate of new bone ingrowth was observed in defects protected with β-TCP silk membranes (Fig. 3,4).

Conclusion

The highest rate of new bone ingrowth was observed in defects protected with β-TCP silk membranes. No other membrane showed a comparable effect on guided bone regeneration with respect to promoting significantly greater bone regeneration and defect bridging.

References

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Fig. 1: Diagram depicting the results of the histomorphometric evaluation of bone formation and ingrowth into the defects (A) and 12 (B) weeks after surgery (Surgery: 2005; 26:147). A: Necrotic bone; B: Bone; C: Total defect volume; D: Bone volume/tot. defect volume. E: Bone volume/tot. defect volume was measured in the cortical and cancellous bone regions (pink bar) and in the total defect volume (black bar). F: Only areas of bony tissue were assessed for bone formation (yellow bar). G: Nonspecific collagen (light yellow bar) and specific collagen (yellow bar) were evaluated in the defect region. H: Discontinuities in bone formation were assessed in the central defect area (red bar) and in the peripheral area (light red bar). I: Bone ingrowth into defects covered with β-TCP modified silk membranes (black bar) was significantly higher than in defects covered with collagen (pink bar) (p<0.05). J: Scans of the defect area obtained in the same animal 10 weeks after surgery (CT scan). K: Diagram depicting the results of the histomorphometric evaluation of bone formation and ingrowth into the defects (A) and 12 (B) weeks after surgery (Surgery: 2005; 26:147). A: Necrotic bone; B: Bone; C: Total defect volume; D: Bone volume/tot. defect volume. E: Bone volume/tot. defect volume was measured in the cortical and cancellous bone regions (pink bar) and in the total defect volume (black bar). F: Only areas of bony tissue were assessed for bone formation (yellow bar). G: Nonspecific collagen (light yellow bar) and specific collagen (yellow bar) were evaluated in the defect region. H: Discontinuities in bone formation were assessed in the central defect area (red bar) and in the peripheral area (light red bar). I: Bone ingrowth into defects covered with β-TCP modified silk membranes (black bar) was significantly higher than in defects covered with collagen (pink bar) (p<0.05). J: Scans of the defect area obtained in the same animal 10 weeks after surgery (CT scan). K: Diagram depicting the results of the histomorphometric evaluation of bone formation and ingrowth into the defects (A) and 12 (B) weeks after surgery (Surgery: 2005; 26:147). A: Necrotic bone; B: Bone; C: Total defect volume; D: Bone volume/tot. defect volume. E: Bone volume/tot. defect volume was measured in the cortical and cancellous bone regions (pink bar) and in the total defect volume (black bar). F: Only areas of bony tissue were assessed for bone formation (yellow bar). G: Nonspecific collagen (light yellow bar) and specific collagen (yellow bar) were evaluated in the defect region. H: Discontinuities in bone formation were assessed in the central defect area (red bar) and in the peripheral area (light red bar). I: Bone ingrowth into defects covered with β-TCP modified silk membranes (black bar) was significantly higher than in defects covered with collagen (pink bar) (p<0.05). J: Scans of the defect area obtained in the same animal 10 weeks after surgery (CT scan). K: Diagram depicting the results of the histomorphometric evaluation of bone formation and ingrowth into the defects (A) and 12 (B) weeks after surgery (Surgery: 2005; 26:147). A: Necrotic bone; B: Bone; C: Total defect volume; D: Bone volume/tot. defect volume. E: Bone volume/tot. defect volume was measured in the cortical and cancellous bone regions (pink bar) and in the total defect volume (black bar). F: Only areas of bony tissue were assessed for bone formation (yellow bar). G: Nonspecific collagen (light yellow bar) and specific collagen (yellow bar) were evaluated in the defect region. H: Discontinuities in bone formation were assessed in the central defect area (red bar) and in the peripheral area (light red bar). I: Bone ingrowth into defects covered with β-TCP modified silk membranes (black bar) was significantly higher than in defects covered with collagen (pink bar) (p<0.05). J: Scans of the defect area obtained in the same animal 10 weeks after surgery (CT scan).

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