



# Ridge Bone Maintenance in Human After Extraction

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**B**uccal alveolar bone defect is a common finding in dentistry as a consequence of advanced periodontal disease, accidental traumatic injury, and surgical trauma during tooth removal or resective periodontal surgery.<sup>1,2</sup> The loss of the buccal alveolar bone most often occurs due to the thin thickness of the buccal plate in both the maxilla and the mandible. As a result, the localized ridge deformities reduce the possibility of rehabilitation with endosseous implants after extraction.<sup>3</sup>

To reduce, and even obviate, such deformities, ridge bone maintenance procedures using biomaterials at the time of tooth extraction, can preserve ridge anatomy so as to increase the possibility of rehabilitation after tooth extraction.<sup>3-5</sup> However, the relative success of these biomaterials depends on many factors including the surgical application and technique as well as properties of the graft itself.<sup>6</sup>

The ability of devitalized bone to induce cellular response resulting in new bone tissue formation has been known for decades.<sup>7-9</sup> Urist et al<sup>9</sup> in

**Purpose:** The aim of this study was to evaluate, clinically and histologically, the tissues formed in human alveolar sockets filled with bovine morphogenetic protein/bovine organic matrix (BOM) and absorbable membrane (AM) immediately after extraction.

**Materials:** Forty-six human alveolar sockets, exhibiting buccal bone defects were selected for this study. Group 1 received no biomaterial to serve as control. Sockets from group 2 were filled with bovine bone morphogenetic protein (bBMP) associated with bOM. The association of bBMP/bOM/AM filled the alveolar defects from group 3. AM was placed over the defects from group 4. Clinical evaluation analyzed ridge width before biomaterial filling and 4 months after filling. Fifteen specimens were collected from groups 2, 3, and 4 for histologic analyses.

**Results:** Clinical results showed no significant augmentation on the control group ( $-0.16 \pm 0.28$  mm). All test sites, groups 2, 3, and 4, showed relevant ridge width augmentation ( $3.0 \pm 0.5$  mm,  $2.4 \pm 0.3$  mm, and  $2.9 \pm 0.6$  mm, respectively) and no resorption. Histologically, all experimental alveolar sockets showed active bone formation with osteoid, osteoblasts, and cell differentiation.

**Conclusion:** On the basis of this study, we concluded that bBMP/bOM with or without AM could preserve the ridge showing viable bone formation for future implant placement. (Implant Dent 2010;19:314-322)

**Key Words:** guided bone regeneration, ridge maintenance, biomaterials, BMP, biological barrier, histologic analysis

1973 demonstrated that this osteoinductive activity could be extracted from the organic component of bone using chemotropic agents and that some proteins were responsible for this activity, naming this group of proteins as bone morphogenetic protein (BMP).<sup>10</sup> BMP is an acidic polypeptide<sup>11</sup> embedded in a complex assortment of intracellular and extracellular protein aggregates derived from dentin,<sup>12</sup> bone,<sup>13,14</sup> and osteosarcoma tissues.<sup>15,16</sup> Under the influence of BMP, perivascular mesenchymal-type cells (pericytes) differentiate into cartilage and woven bone.<sup>17</sup> This protein in association with organic matrix can increase the new bone formation due to

counterregulatory factors present in demineralized bone but not in purified BMP preparation.<sup>18</sup>

In dentistry, grafts have been used in association with biological barriers. The membranes can exclude the epithelial and connective tissues in the alveolar healing site guiding a selective cell population into the bone defect, contributing to ridge maintenance. In addition, the absorbable membrane (AM) does not require a second surgical procedure for its removal.<sup>19</sup> The aim of this study was to evaluate the tissues formed in human alveolar sockets filled with bovine bone morphogenetic protein (bBMP)/bovine organic

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matrix (BOM) and AM immediately after extractions.

## MATERIALS AND METHODS

Clinical procedures of this study were submitted and approved by Ethics Committee of Federal Fluminense University-Medicine School (CEP CMM/HUAP no. 94/03) under the law no. 196/96 of the National Ethics Research Committee from Brazil.

### Biomaterials

The biomaterials (Genius/Baumer S.A., São Paulo, Brazil) used in this research were composed of bBMP, bOM, and AM. The bBMPs were extracted from fetal BOM by biochemistry process. The carriers for bBMP were hydroxyapatite (HA) on a 1:20 (bBMP/HA) ratio. The association of bBMP/bOM microgranulated were used on a ratio of 1:4 (bBMP/bOM) and mixed with 0.9% of sodium chloride until obtaining a homogeneous aspect. The AM used was composed of bovine collagen.

### Ridge Maintenance Procedure

Forty-six human alveolar sockets from single- or multi-rooted teeth in maxillary or mandible were selected in 19 patients. All alveolar sockets included in this study exhibited buccal bone defects after extraction. During the extraction procedure, all remnant alveolar bone was preserved. The alveolar sockets were separated in 4 groups. Group 1 (11 sockets) received no biomaterial and served as control. Sockets from group 2 (11 sockets) were filled with bBMP associated with bOM. The association bBMP/bOM/AM filled the alveolar defects on group 3 (12 sockets). AM was placed over the defects on group 4 (12 sockets).

The surgery for ridge maintenance was performed under local anesthesia. The incisions extended to the bone surface and mucoperiosteal flaps were elevated. After this procedure, the extractions were performed. On groups 2, 3 and 4, the biomaterials were immediately placed after extractions until the level of the ridge. Flaps were coronally repositioned to completely cover the sockets and sutured with 3-0 silk sutures achieving primary closure.

All patients were submitted to weekly evaluation during the healing period of 4 months at Federal Fluminense University Dental School, Rio de Janeiro, Brazil.

### Clinical Procedures

Clinical procedures were standardized using an acrylic stent to analyze ridge width before biomaterial filling and 4 months after surgery. After tooth extraction, the acrylic stent was placed over the surgical site and a probe was vertically used to identify and register the center of the buccal defect. Using a spherical drill, 2 notches (buccal and lingual) were then made on the acrylic stent. All references were immediately registered. A caliper was used to measure the initial thickness of the ridge. After 4 months, the acrylic stent was readapted and the references were reproduced. The final thickness of the ridge was measured and registered.

### Histologic Procedures

Fifteen specimens were collected from groups 2, 3, and 4, using a trephine, for histologic analyzes after 4 months. This procedure was performed at the same time of the final clinical analysis. The specimens were rinsed in sterile saline, fixed in 70% ethanol and then dehydrated in graded ethanol before be embedded in methylmethacrylate. Five-micrometer sections were cut using a microtome equipped with a disposable carbide steel knife. Sections were further stained with Goldner Trichrome and examined under light microscopy for evaluation of bone formation.

### Statistical Analysis

Normality and homocedasticity were tested with the Shapiro-Wilk's and Levene's tests, respectively. Assessment of differences between final and initial thicknesses was performed by ANOVA to compare groups and Tahmane's T2 statistic to perform multiple comparisons. The level of significance was set at  $\alpha = 0.05$ .

## RESULTS

### Clinical Analysis

Healing following the augmentation procedure progressed unevent-

fully. There was no exposure of any biomaterial. The augmented alveolar ridge exhibited the same hardness on palpation as the adjacent alveolar structures. The control group showed no statistically significant augmentation. In contrast, on the test sites, groups 2, 3, and 4, relevant ridge augmentation was observed. No significant difference was observed between these test groups (Graph 1 and Table 1).

### Histopathologic Analysis

All test groups showed active bone formation with plump osteoblasts and osteoid matrix deposition, osteocyte, and undifferentiated cells. In group 2, intense bone formation was present in all samples (Fig. 1). Group 3 also showed neoformed bone with osteoblastic activity (Fig. 2). Bone neoformation was surrounded by many blood vases and undifferentiated cells in group 4 (Fig. 3).

## DISCUSSION

The bone ridge can be reduced by 25% in thickness at the first year after tooth extraction, and it can increase rapidly from 30% to 40% in 3 years.<sup>20</sup> As a result, even an intact socket after extraction showing 6 to 8 mm in thickness can be improper to rehabilitation after 1 year, and it can show no available bone after 3 years. Researches have demonstrated that the ridge bone maintenance procedures, using biomaterials at the time of extraction, decrease the bone loss and increase the possibility of rehabilitation after tooth extraction.<sup>4,5</sup> In addition, this technique could maintain adjacent soft tissue (papillae) height and promote optimal implant aesthetics.<sup>21</sup>

Various types of bone grafting material have been suggested for socket augmentation, and some have shown promising results. Coverage of the grafted extraction site with wound dressing materials, coronal flap advancement, or even barrier membranes may enhance wound stability and an undisturbed healing process.<sup>22</sup> Our study evaluated clinical and histologically the tissues formed in human alveolar sockets presenting buccal bone defects using bBMP, bOM, and AM immediately after extraction.

BMP-based products have been available for clinical use in several applications in which bone induction is desired. These BMP-based products include recombinant human BMP-2, recombinant human BMP-7, and growth and differentiation factor type 5. The bovine BMP extract is purified from bovine bone, and therefore contains a mixture of BMP molecules and other noncollagenous proteins derived from bone. However, many counterregulatory factors required to new bone formation are present in demineralized bone but not in purified BMP preparations.<sup>18</sup> Therefore, the association of bBMP/bOM on a 1:4 ratio was used in our study.

In our clinical results, group 1 (filled only with clot-control) showed

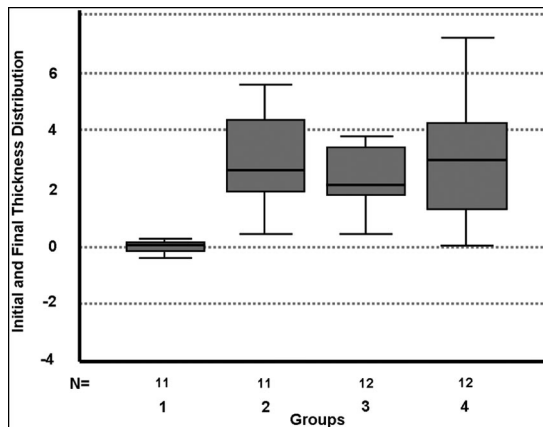
no capacity to maintain the ridge. This group showed critic chronic buccal defects after 4 months. In contrast, all test groups presented a satisfactory bone growth average, which can be interpreted as efficient ways to maintain the ridge after teeth extraction. The association bBMP/bOM/AM used in group 3 of our study, allowed homogenous bone growth in all sites. However, the largest variation between the initial and the final ridge thickness occurred in group 4 (AM), which can be explained by the collapse of the membrane in 2 samples. Even though the membrane can be used alone as a maintenance procedure in extraction sites with buccal defects, if the membrane collapses, due to the

lack of support, no benefit should be expected.

Therefore, the association between bone grafts and AM, immediately placed after tooth extraction showing buccal defects, to maintain the bone ridge, has demonstrated to be efficient, fulfilling the bone defects and preventing the membrane collapse as related in other studies.<sup>3,19,23</sup>

An important aspect of the osteoinductivity of the BMP is the carrier selection. The carrier serves as an osteoconductive matrix and it keeps the osteogenic factors concentration high enough to allow the migration, proliferation, and differentiation of cells.<sup>24</sup> The HA-like carrier sustains greater physical strength and it can be resorbed during a period of 3 to 4 months.<sup>25</sup> In fact, our results showed that the HA carrier did not interfere with bone formation, indicating its use as a carrier to bBMP for guided bone regeneration.

Wang et al<sup>22</sup> in 2004 presented positive outcomes with minimal morphologic changes noticeable up to 6 months after extraction using barrier membranes to enhance wound stability. The Bio-Col technique, proposed by Sclar<sup>26</sup> in 1999 uses bovine HA bone graft (bottom, two thirds), covers with an absorbable collagen dressing (top, one third) and seals with tissue glue. The author claimed that this technique prevents the loss of both hard and soft tissues, reduces the num-



**Graph 1.** Initial and final thickness distribution in all groups (in mm). Note that box plot of group 1 (control) shows no statistically significant difference from baseline to final thickness. Box plots of groups 2, 3, and 4 present the same pattern of distribution, revealing relevant augmentation.

**Table 1.** Clinical Measurements of the Alveolar Ridges Thickness (in mm)

| Subjects | Group 1 (Control) |       |        | Group 2 (bBMP/bOM) |       |        | Group 3 (bBMP/bOMtAM) |       |        | Group 4 (AM) |       |        |
|----------|-------------------|-------|--------|--------------------|-------|--------|-----------------------|-------|--------|--------------|-------|--------|
|          | Initial           | Final | Change | Initial            | Final | Change | Initial               | Final | Change | Initial      | Final | Change |
| 1        | 3.6               | 2.5   | -1.1   | 0.2                | 3.4   | 3.2    | 1.2                   | 3.0   | 1.8    | 2.4          | 2.4   | 0.0    |
| 2        | 1.0               | 0.6   | -0.4   | 0.6                | 5.8   | 5.2    | 2.2                   | 4.0   | 1.8    | 2.6          | 6.2   | 3.6    |
| 3        | 0.2               | 0.2   | 0.0    | 0.4                | 4.8   | 4.4    | 1.6                   | 5.2   | 3.6    | 1.8          | 6.8   | 5.0    |
| 4        | 4.0               | 2.8   | -1.2   | 1.0                | 5.2   | 4.2    | 0.2                   | 3.0   | 2.8    | 1.4          | 4.6   | 3.2    |
| 5        | 0.6               | 0.4   | -0.2   | 0.8                | 2.4   | 1.6    | 0.8                   | 2.8   | 2.0    | 1.2          | 2.6   | 1.4    |
| 6        | 2.2               | 2.2   | 0.0    | 0.8                | 6.4   | 5.6    | 1.6                   | 3.8   | 2.2    | 0.2          | 2.4   | 2.2    |
| 7        | 0.2               | 0.8   | 0.6    | 6.0                | 6.4   | 0.4    | 4.6                   | 5.0   | 0.4    | 2.2          | 2.2   | 0.0    |
| 8        | 2.0               | 2.9   | 0.9    | 1.2                | 3.2   | 2.0    | 0.4                   | 4.2   | 3.8    | 0.8          | 2.0   | 1.2    |
| 9        | 0.8               | 1.0   | 0.2    | 0.2                | 2.8   | 2.6    | 0.4                   | 2.4   | 2.0    | 0.4          | 7.6   | 7.2    |
| 10       | 0.8               | 0.6   | -0.2   | 0.6                | 3.2   | 2.6    | 1.6                   | 3.4   | 1.8    | 0.8          | 4.2   | 3.4    |
| 11       | 1.2               | 0.8   | -0.4   | 3.0                | 4.8   | 1.8    | 0.6                   | 4.2   | 3.6    | 0.2          | 5.0   | 4.8    |
| 12       |                   |       |        |                    |       |        | 1.0                   | 4.2   | 3.2    | 1.0          | 3.8   | 2.8    |
| Mean     | 1.51              | 1.35  | -0.16  | 1.35               | 4.40  | 3.05   | 1.35                  | 3.77  | 2.42   | 2.5          | 4.1   | 2.90   |
| SD       | —                 | —     | 0.28   | —                  | —     | 0.5    | —                     | —     | 0.3    | —            | —     | 0.6    |

SD, standard deviation.

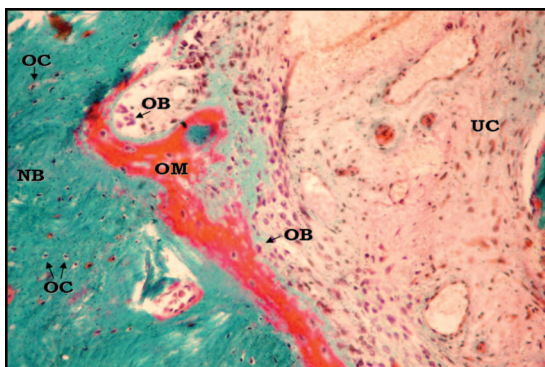


**Fig. 1.** Histopathologic aspect in group 2. Osteoblasts (OB), osteoid matrix (OM), neoformed bone (NB), osteocytes (OC), and undifferentiated cells (UC).

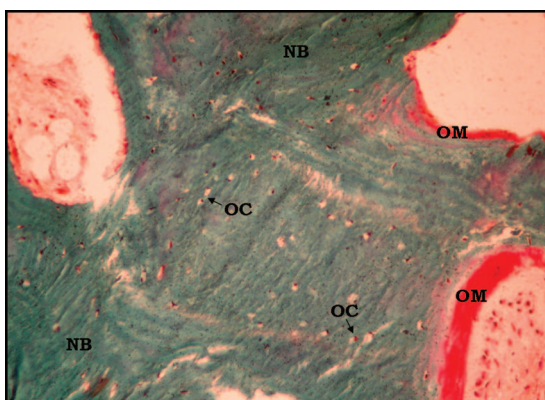


**Fig. 2.** Histopathologic aspect in group 3. Neoformed bone (NB), osteocytes (OC), and osteoid matrix (OM).

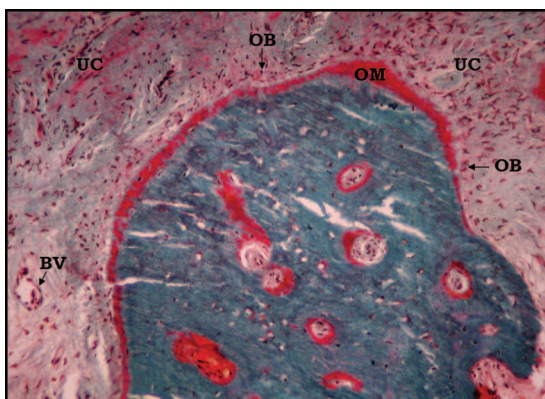


**Fig. 3.** Histopathologic aspects in group 4. Undifferentiated cells (UC), osteoblasts (OB), osteoid matrix (OM), and blood vessel (BV).

were observed. Groups 3 and 4 showed intense cell selectiveness, which could be associated to the use of AM. These results suggest that the biomaterials used in this study are suitable for socket augmentation.

## CONCLUSION

On the basis of this study, we concluded that bBMP/bOM, with or without AM, could preserve the ridge showing viable bone formation for future implant placement. The membrane, when used in extraction sites with buccal defects, should be associated with a grafting material to avoid its collapse. According to our analysis, 4 months were enough to promote bone formation.

## Disclosure

The authors declare that they do not have any affiliation with any product or company.

## REFERENCES

1. Abrams L. Augmentation of the deformed residual edentulous ridge for fixed prosthesis. *Comp Cont Educ Dent*. 1980;1: 205-213.
2. Atwood DA. Some clinical factors related to rate of resorption of residual ridges. *J Prosthet Dent*. 2001;2:119-125.
3. Barboza EP. Localized ridge maintenance using bone membrane. *Implant Dent*. 1999;8:167-172.
4. Barteck BK. Extraction site reconstruction for alveolar ridge preservation. Part 1: Rationale and materials selection. *J Oral Implantol*. 2001;27:187-193.
5. Becker W, Hujuel P, Becker BE. Effect of barrier membrane and autologous bone grafts on ridge width preservation around implants. *Clin Implant Dentist Relat Res*. 2002;4:143-149.
6. Wozney JM. Overview of bone morphogenetic proteins. *Spine*. 2002;27: S2-S8.
7. Kamijou T, Nakajima T, Ozawa H. Effects of osteocytes on osteoinduction in the autogenous rib graft in the rat mandible. *Bone*. 1994;15:629-637.
8. Misch CE, Dietsh F. Bone-grafting materials in implant dentistry. *Implant Dent*. 1993;2:158-167.
9. Urist MR, Iwata H, Ceccotti PL, et al. Bone morphogenetic protein in implants of insoluble bone gelatin. *Proc Natl Acad Sci USA*. 1973;70:3511-3515.
10. Urist MR, Mikulski A, Lietze A. Solubilized and insolubilized bone morphoge-

ber of surgical interventions, and provides optimum esthetics with greater predictability. However, Artzi et al<sup>27</sup> have shown that there are bovine HA particles remaining on the site even after 4 months of healing. Therefore, there is a need to identify alternate bone

grafts that could be quickly replaced by the host bone. In our study, all test groups, histopathologically, showed intense activity of bone formation characterized by the presence of osteoblast and undifferentiated cells. After 4 months, no remnants of biomaterial particles

netic protein. *Proc Natl Acad Sci USA*. 1979;76:1828-1832.

11. Urist MR, Sato K, Brownell A, et al. Human bone morphogenetic protein (hBMP). *Proc Soc Exp Biol Med*. 1983;173:194-199.

12. Conover MA, Urist MR. In: Proceedings of the First International Conference on Chemistry and Biology of Mineralized Connective Tissue. New York: Elsevier;1982:597.

13. Mizutani H, Urist MR. The nature of bone morphogenetic protein (BMP) fractions derived from bovine bone matrix gelatin. *Clin Orthop Relat Res*. 1982;171:213-223.

14. Urist MR, Lietze AM, Mizutani H, et al. A bovine low molecular weight bone morphogenetic protein (BMP) fraction. *Clin Orthop Relat Res*. 1982;162:219-232.

15. Bauer FC, Urist MR. Human osteosarcoma-derived soluble bone morphogenetic protein. *Clin Orthop Relat Res*. 1981;154:291-295.

16. Hanamura H, Higuchi Y, Nakagawa M, et al. Solubilization and purification of bone morphogenetic protein (BMP)

from Dunn osteosarcoma. *Clin Orthop Relat Res*. 1980;153:232-240.

17. Urist MR, Huo YK, Brownell AG, et al. Purification of bovine morphogenetic protein by hydroxyapatite chromatography. *Proc Natl Acad Sci USA*. 1984;81:371-375.

18. Jortikka L, Marttinen A, Lindholm TS. Purification of monocomponent bovine bone morphogenetic protein a water-soluble form. *Ann Chir Gynaecol*. 1993;82:25-30.

19. Barboza EP. Clinical and histological evaluation of the demineralized freeze-dried bone membrane used for ridge augmentation. *Int J Periodontics Restorative Dent*. 1999;19:601-607.

20. Nemcovsky CE, Serfaty V. Alveolar ridge preservation following extraction of maxillary anterior teeth: Report on 23 consecutive cases. *J Periodontol*. 1996;67:390-395.

21. Wang HL, Tsao XP. Mineralized bone allograft-plug socket augmentation: Rational and technique. *Implant Dent*. 2007;16:33-41.

22. Wang HL, Klyonobu K, Neiva RF.

Socket augmentation: Rationale and technique. *Implant Dent*. 2004;13:286-296.

23. Barboza EP. Regeneration of surgically reduced alveolar ridges utilizing demineralized freeze-dried bone cortical columns and membrane in dogs: A clinical and histological study. Boston University; 1993 [Thesis].

24. Seeherman H, Wozney J, Li R. Bone morphogenetic protein delivery systems. *Spine*. 2002;27:S16-S23.

25. Schliephake H. Bone growth factors in maxillofacial skeletal reconstruction. *Int J Oral Maxillofac Surg*. 2002;31:469-484.

26. Sclar AG. Preserving alveolar ridge anatomy following tooth removal in conjunction with immediate implant placement. The Bio-Col technique. *Atlas Oral Maxillofac Surg Clin North Am*. 1999;7:39-59.

27. Artzi Z, Tal H, Dayan D. Porous bovine bone mineral in healing of human extraction sockets. Part 1: Histomorphometric evaluation at 9 months. *J Periodontol*. 2000;71:1015-1023.



## Abstract Translations

### GERMAN / DEUTSCH

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**Erhaltung des Kammknochens beim Menschen nach erfolgter Zahnextraktion**

**ZUSAMMENFASSUNG: Zielsetzung:** Die vorliegende Studie zielte darauf ab, die Gewebe klinisch sowie histologisch zu untersuchen und zu bewerten, die in den alveolären Pfannen beim Menschen gebildet werden. Diese wurden mit morphogenetischem Protein vom Rind/organischer Rindermatrix sowie einer absorbierbaren Membrane direkt nach dem Extraktionseingriff gefüllt. **Materialien und Methoden:** 46 menschliche alveoläre Pfannen mit Knochengewebsdefekten im Wangenbereich wurden für diese Studie ausgewählt. Versuchsgruppe 1 erhielt keinerlei Biomaterial und fungierte damit als Kontrollgruppe. Die Pfannen der Gruppe 2 wurden mit morphogenetischem Knochenprotein vom Rind (bBMP) in Verbindung mit organischer Rindermatrix (bOM) angefüllt. Eine Kombination aus bBMP/bOM und absorbierbarer Membrane (AM) füllte die alveolären Defekte der Gruppe 3. Die Defekte wurden bei Gruppe 4 mit einer absorbierbaren Membrane abgedeckt. Die klinische Bewertung erfolgte über eine Analyse der Kammweite vor Einfüllung des Biomaterials

sowie 4 Monate nach Füllung. Zur histologischen Analyse wurden insgesamt 15 Proben aus den Gruppen 2, 3 und 4 gewonnen. **Ergebnisse:** Die klinischen Ergebnisse wiesen keine bedeutsame Anreicherung bei der Kontrollgruppe auf ( $-0,16 \pm 0,28$  mm). Alle Testbereiche der Gruppen 2, 3 und 4 zeigten eine maßgebliche Anreicherung der Kammweite ( $3,0 \pm 0,5$  mm,  $2,4 \pm 0,3$  mm bzw.  $2,9 \pm 0,6$  mm) und keinerlei Resorption. Aus histologischer Sicht wiesen alle zur Untersuchung verwendeten alveolären Pfannen eine aktive Knochenbildung mit einer klaren Differenzierung von Osteoiden, Osteoblasten und Zellen auf. **Schlussfolgerung:** Auf der Grundlage dieser Studie zogen wir den Schluss, dass durch bBMP/bOM mit oder ohne AM die Möglichkeit besteht, dass der Kamm unter Bildung von lebensfähigem Knochengewebe zur zukünftigen Implantatsetzung erhalten bleibt.

**SCHLÜSSELWÖRTER:** geführte Knochengewebsregeneration, Kammerhaltung, Biomaterialien, morphogenetisches Knochenprotein, biologische Barriere, histologische Analyse

### SPANISH / ESPAÑOL

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## Mantenimiento del hueso cresta en humanos luego de la extracción

**ABSTRACTO: Propósito:** El objetivo de este estudio fue evaluar, clínica e histológicamente, los tejidos formados en las cavidades alveolares humanas llenas con matriz orgánica bovina/proteínas morfogenéticas bovinas y una membrana absorbible inmediatamente después de la extracción. **Materiales y métodos:** Se seleccionaron cuarenta y seis cavidades alveolares humanas, con defectos en el hueso bucal, para este estudio. El grupo 1 no recibió ningún biomaterial y sirvió como control. Las cavidades del grupo 2 se llenaron con proteínas morfogenéticas de hueso bovino (bBMP por sus siglas en inglés) asociada con la matriz orgánica bovina (bOM por sus siglas en inglés). La asociación de bBMP/bOM/membrana absorbible (AM por sus siglas en inglés) llenó los defectos alveolares en el grupo 3. La membrana absorbible se colocó sobre los defectos del grupo 4. La evaluación clínica analizó el ancho cresta antes del relleno con biomateriales y 4 meses después del llenado. Se recolectaron quince muestras de los grupos 2, 3 y 4 para su análisis histológico. **Resultados:** Los resultados clínicos demostraron ningún aumento en el grupo de control ( $-0,16 \pm 0,28$  mm). Todos los lugares de prueba en los grupos 2, 3 y 4 demostraron un aumento importante del ancho de la cresta ( $3,0 \pm 0,5$  mm,  $2,4 \pm 0,3$  mm y  $2,9 \pm 0,6$  mm, respectivamente) y sin reabsorción. Histológicamente, todas las cavidades alveolares experimentales demostraron una formación activa de hueso con osteoides, osteoblastos y diferenciación celular. **Conclusión:** Basado en este estudio, hemos concluido que bBMP/bOM con o sin AM podría preservar la cresta demostrando una formación viable del hueso para la colocación futura del implante.

**PALABRAS CLAVES:** Regeneración guiada del hueso, mantenimiento de la cresta, biomateriales, proteínas morfogenéticas de hueso, barrera biológica, análisis histológico

## PORTUGUESE / PORTUGUÊS

**AUTOR(ES):** Priscila Ladeira Casado, Mestre em Odontologia, Maria Eugênia Leite Duarte, PhD, Waldimir Carvalho, Mestre em Odontologia, Licínio Esmeraldo da Silva, Mestre em Ciência, Eliane Porto Barboza, Mestre em Odontologia **Manutenção do osso do rebordo em humanos após extração**

**RESUMO: Objetivo:** O objetivo deste estudo foi avaliar, clínica e histologicamente, os tecidos formados em alvéolos humanos preenchidos com proteína morfogenética bovina/matriz orgânica bovina e membrana absorvível imediatamente após a extração. **Materiais e Métodos:** Quarenta e seis alvéolos humanos, exibindo defeitos dos ossos bucais, foram selecionados para este estudo. O Grupo 1 não recebeu nenhum biomaterial para servir como controle. Os alvéolos do grupo 2 foram preenchidos com Proteína Morfogenética bovina do Osso (bBMP) associada com Matriz Orgânica bovina

(bOM). A associação de bBMP/bOM/membrana absorvível (AM) preencheu os defeitos alveolares do grupo 3. A membrana absorvível foi colocada sobre os defeitos do grupo 4. A avaliação clínica analisou a largura do rebordo antes do preenchimento com biomaterial e 4 meses após o preenchimento. Quinze espécimes foram coletados dos grupos 2, 3 e 4 para análises histológicas. **Resultados:** Os resultados clínicos não mostraram nenhum aumento significativo no grupo de controle ( $-0,16 \pm 0,28$  mm). Todos os locais de teste, os grupos 2, 3 e 4, mostraram relevante aumento da largura do rebordo ( $3,0 \pm 0,5$  mm,  $2,4 \pm 0,3$  mm e  $2,9 \pm 0,6$  mm, respectivamente) e nenhuma reabsorção. Histologicamente, todos os alvéolos experimentais mostraram formação de osso com osteóide, osteoblastos e diferenciação celular. **Conclusão:** Baseados neste estudo, concluímos que bBMP/bOM com ou sem AM poderia preservar o rebordo mostrando formação de osso viável para futura colocação de implante.

**PALAVRAS-CHAVE:** regeneração guiada do osso, manutenção do rebordo, biomateriais, proteína morfogenética do osso, barreira biológica, análise histológica

## RUSSIAN / РУССКИЙ

**АВТОРЫ:** Priscila Ladeira Casado, магистр стоматологии, Maria Eugênia Leite Duarte, доктор философии, Waldimir Carvalho, магистр стоматологии, Licínio Esmeraldo da Silva, магистр естественных наук, Eliane Porto Barboza, магистр стоматологии

**Сохранение гребня альвеолярного отростка у человека после удаления зубов**

**РЕЗЮМЕ. Цель.** Целью данного исследования являлся клинический и гистологический анализ тканей, сформированных в лунке зуба у человека при заполнении ее бычьим морфогенетическим белком, бычьим органическим матриксом и рассасывающейся мембраной сразу же после удаления зуба. **Материалы и методы.** Для данного исследования были отобраны сорок шесть лунок зубов с дефектами буккальной кости. Группа 1 выступала в качестве контрольной группы, и для нее биоматериал не использовался. Лунки из группы 2 были заполнены бычьим костным морфогенетическим белком (bBMP) в сочетании с бычьим органическим матриксом (bOM). Альвеолярные дефекты в группе 3 были заполнены комбинацией бычьего костного морфогенетического белка, бычьего органического матрикса и рассасывающейся мембраны. В группе 4 рассасывающуюся мембрану размещали поверх дефектов. Ширина гребня оценивалась посредством клинического анализа до введения биоматериала и 4 месяца спустя. Для гистологического анализа были отобраны пятнадцать образцов из групп 2, 3 и 4. **Результаты.** Клинические результаты выявили от-

существование существенного увеличения ширины в контрольной группе ( $-0,16 \pm 0,28$  мм). Группы 2, 3 и 4 продемонстрировали существенное увеличение ширины гребня в исследуемой области ( $3,0 \pm 0,5$  мм,  $2,4 \pm 0,3$  мм и  $2,9 \pm 0,6$  мм соответственно) и отсутствие резорбции. Гистологический анализ показал, что во всех экспериментальных лунках зубов происходило активное костеобразование наряду с формированием остеонной ткани, остеобластов и дифференцировкой клеток. **Вывод.** Исходя из результатов данного исследования было сделано заключение о том, что применение комбинации бычьего костного морфогенетического белка и бычьего органического матрикса с использованием рассасывающейся мембраны или без нее может сохранить гребень и способствовать формированию жизнеспособной костной ткани для последующей установки имплантата.

**КЛЮЧЕВЫЕ СЛОВА:** направленная регенерация костной ткани, сохранение гребня, биоматериалы, костный морфогенетический белок, биологический барьер, гистологический анализ

## TURKISH / TÜRKÇE

**YAZARLAR:** Priscila Ladeira Casado, MSD, Maria Eugênia Leite Duarte, PhD, Waldimir Carvalho, MSD, Licinio Esmeraldo da Silva, MS, Eliane Porto Barboza, MSD  
**Diş Çekiminden Sonra İnsanlarda Kret Kemisinin Bakımı**

**ÖZET: Amaç:** Bu çalışmanın amacı, diş çekiminden hemen sonra bovin morfogenetik protein/bovin organik matrisi ve abzorabl membran ile doldurulmuş insan alveoler soketlerinde oluşan dokuları klinik ve histolojik açılarından değerlendirmektir. **Gereç ve Yöntem:** Bu çalışmaya, bukkal kemik defektleri olan 46 insan alveoler soketi dahil edildi. 1. Grup kontrol grubu olarak seçilerek, bu gruptaki olgulara biyomateryal uygulanmadı. 2. Grubun soketleri, bovin Organik Matris (bOM) ile bağlantılı Bovin Morfogenetik Proteini (bBMP) ile dolduruldu. 3. Grubun alveoler defektlerini doldurmak için bBMP/bOM/abzorabl membran bileşimi kullanıldı. 4. Grubun defektlerinin üzerinde abzorabl membran yerleştirildi. Biyomateryal doldurma işleminden önce ve doldurmadan 4 ay sonra klinik değerlendirme ile kret genişliği analiz edildi. Histolojik analiz için 2., 3., ve 4. Gruplardan 15 örnek alındı. **Bulgular:** Klinik sonuçlar, kontrol grubunda önemli ölçüde büyüme olmadığını gösterdi ( $-0,16 \pm 0,28$  mm). 2., 3., ve 4. Gruplardaki tüm test yerleri kret genişliğinde ogmantasyon (sırasıyla  $3,0 \pm 0,5$  mm,  $2,4 \pm 0,3$  mm ve  $2,9 \pm 0,6$  mm) gösterdi ve rezorpsiyon görülmedi. Histolojik olarak tüm alveoler deney soketlerinde osteoid ve osteoblastlar ile birlikte hücre farklılaşması ve bu şekilde, aktif kemik oluşumu gözlemlendi. **Sonuç:** Bu çalışma sonuçlarına dayanarak, abzorabl membran ile birlikte veya abzorabl membran olmadan bBMP/bOM kullanımının canlı kemik formasyonu ile kreti korumak suretiyle ileride implant yerleştirmeye olanak sağlayacağı kanaatine varıldı.

**ANAHTAR KELİMELE:** kılavuzlu kemik rejenerasyonu, kret bakımı, biyomateryaller, kemik morfogenetik proteini, biyolojik bariyer, histolojik analiz

## JAPANESE / 日本語

## ヒトにおける抜歯後の歯槽堤骨保存

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## 研究概要:

目的: 当研究目的は抜歯直後ウシ骨由来骨形成蛋白質/ウシ骨由来オーガニックマトリックスそして吸収性メンブレンをヒトの歯槽堤抜歯ソケットに補填し、そこで形成した骨組織を臨床と組織学の両見地で評価することである。

素材と方法: 当研究には頬側欠損歯槽堤骨の徴候を示す46のヒト歯槽堤抜歯ソケットを対象にした。グループ I はバイオマテリアルを補填せずコントロールグループとした。グループ2の抜歯ソケットはウシ由来オーガニックマトリックス(bOM)にウシ由来骨形成蛋白質(bBMP)を結合し補填した。グループ3の欠損歯槽堤骨はbBMP/bOM/吸収性メンブレン(AM)結合材で補填した。グループ4は欠損骨上に吸収性メンブレンを設置した。バイオマテリアル補填前と補填後4ヶ月目の歯槽堤骨を臨床評価した。グループ2、3、4から組織学的評価用に15の試料を採取した。

結果: 臨床結果ではコントロールグループには際立った骨増加は確認されなかった ( $-0.16 \pm 0.28$  mm)。グループ2、3、4のテスト部位ではそれぞれに相当する歯槽幅増大が確認され、(各  $3.0 \pm 0.5$  mm、 $2.4 \pm 0.3$  mm、 $2.9 \pm 0.6$  mm) 骨吸収は見られなかった。組織的評価ではすべての試験歯槽堤骨抜歯ソケットに類骨や骨芽細胞そして細胞分化を伴う活発な骨形成が見られた。

結論: 当研究に基づきAMの有無にかかわらず、bBMP/bOMは今後インプラント埋入手術を可能にする骨形成が見られ歯槽堤骨保存可能という結論に達した。

キーワード: 骨再生誘導療法; 歯槽堤骨保存、バイオマテリアル、骨形成蛋白質、生物学的バリア、組織学的評価

## CHINESE / 中国語

## 人類拔牙後の脊骨維護

作者: Priscila Ladeira Casado, MSD, Maria Eugênia Leite Duarte, PhD, Waldimir Carvalho, MSD, Licinio Esmeraldo da Silva, MS, Eliane Porto Barboza, MSD

## 摘要:

目的: 本研究の目的は針對人類拔牙後立即以牛骨塑型蛋白/牛有機基質和可吸收膜填補齒槽窩進行臨床和組織學方面的評估。

資料與方法: 本研究選擇 64 個出現頰側骨缺損的人類齒槽窩。第一組為對照組, 不使用生物材料; 第二組的齒槽窩以牛有機基質 (bOM) 和牛骨塑型蛋白 (bBMP) 的結合填補; 第三組以bBMP/bOM/可吸收膜 (AM) 的結合填補齒槽缺損; 第四組則以可吸收膜置於缺損上。使用生物材料填補之前和填補 4 個月之後, 以臨床評估分析牙脊寬度。從第二、第三和第四組採集15個樣本以進行組織學分析。

結果: 臨床結果顯示, 對照組的牙脊寬度並沒有顯著增加 ( $-0.16 \pm 0.28$  mm); 第二、第三和第四組所有測試部位的牙脊寬度則都出現有意義增加 (分別為  $3.0 \pm 0.5$  mm、 $2.4 \pm 0.3$  mm 和  $2.9 \pm 0.6$ ), 且都沒有流失的情況。從組織學的角度來看, 所有實驗的齒槽窩都出現類骨質、造骨細胞和細胞差異的有效骨形成。

結論: 根據本研究, 我們的結論是無論有無 AM, bBMP/bOM 的骨質形成作用所維護的牙脊都可以做為未來植體置入使用。

關鍵字: 引導骨質再生術、牙脊維護、生物材料、骨塑型蛋白、生物障礙、組織學分析。

## KOREAN / 한국어

## 발치 후 인체 치조골 관리

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**요약:**

**목적:** 본 연구의 목적은 발치 후 즉시 소 형태형성단백/소 유기바탕질 및 흡수성 막으로 채워진 치조소켓에 형성된 조직을 임상적 및 조직학적으로 평가하는데 있다.

**재료 및 방법:** 험골 결손을 보이는 46명의 치조 소켓을 본 연구의 대상으로 선택하였다. 1군은 대조군으로 어떠한 생체 적합물질도 적용하지 않았다. 2군의 소켓에는 소 유기바탕질과 연관된 소 골 형태형성 단백질로 충전하였다. bBMP/bOM/흡수성 막(AM)으로 3군의 치조 결손 부위를 충전하였다. 4군의 경우는 흡수성 막을 결손 부위에 매식하였다. 생체 적합물질 충전 전과 충전 4개월 이후 능선폭을 임상적으로 분석하였다. 조직 분석을 위해 2, 3, 4 군으로부터의 15 검체를 채집하였다.

**결과:** 임상적 결과, 평가 시 대조군의 경우 어떠한 유의한 증대도 나타나지 않았다 ( $-0.16 \pm 0.28$  mm). 2, 3 및 4 군의 모든 시험 부위에서 능선폭 증대(각각  $3.0 \pm 0.5$  mm,  $2.4 \pm 0.3$  mm 및  $2.9 \pm 0.6$  mm)를 보였고, 흡수는 나타나지 않았다. 조직학적으로, 모든 실험 치조소켓은 유골, 골모 세포 및 세포 분화와 함께 활성 골 형성을 나타냈다.

**결론:** 본 연구를 토대로 AM 유무와 관계없이 bBMP/bOM는 이후 임플란트 식립을 위한 생육가능 골 형성을 보이는 능선을 보존할 수 있다고 결론지었다.

**키워드:** 유도 골 재생, 치조능선 유지, 생체 적합물질, 골 형태형성 단백질, 생물학적 장벽, 조직학적 분석.