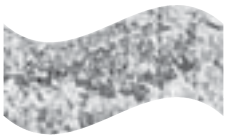
Società Italiana
di Parodontologia



Ridge alterations at implants placed into fresh extraction sockets

Impianto post-estrattivo immediato. Alterazioni dimensionali della cresta

Fabio VIGNOLETTI*, Massimo DE SANCTIS, Tord BERGLUNDH***, Ingemar ABRAHAMSSON***, Mariano SANZ***

** Universidad Complutense de Madrid, Spain; ** Universitá degli Studi di Siena, Italy; *** University of Gothenburg, Sweden*

ATTI DELLA SESSIONE DI RICERCA - PREMIO "HENRY M. GOLDMAN" 2009 / *PROCEEDINGS BOOK RESEARCH SESSION – "HENRY M. GOLDMAN" PRIZE 2009*

Summary

This experimental study investigates the early healing of implants placed into fresh extraction sockets. The aim of the communication is to describe the remodelling of the buccal crest at 4 hours, 1, 2, 4 and 8 weeks. The results of the histometric analysis revealed that ridge healing cursed with marked vertical bone resorption that was more pronounced when implants adapted more intimately to the socket walls.

Riassunto

Questo lavoro sperimentale studia il processo di guarigione iniziale conseguente il posizionamento di impianti post-estrattivi. L'obiettivo della comunicazione é descrivere il rimodellamento della parete vestibolare dell'alveolo, 4 ore, 1, 2, 4 e 8 settimane dopo l'inserimento dell'impianto. I risultati dell'analisi istometrico dimostrano un riassorbimento osseo marcato, che risulta essere piú accentuato quando l'impianto é in intimo contatto con le pareti alveolari.

Introduction

In recent years, immediate implant placement after tooth extraction has become a more common surgical protocol. Different clinical investigations have reported short-term high survival rates (approximately 95%), similar to implants placed in healed alveolar ridges (Schwartz-Arad et al. 2007). The healing of immediate implants has also shown a similar histological pattern of osseointegration in both human (Pao-

lantonio et al. 2001) and animal experimental studies (Anneroth et al. 1985). Nevertheless, histometric findings from recent animal studies have revealed that the placement of implants in fresh extraction sockets is associated with marked alterations of the buccal and lingual socket walls, both in terms of height and width (Araujo et al. 2005). When this surgical protocol was compared experimentally to the conventional protocol of implant placement into a healed ridge, Botticelli et al. (2006) demonstrated significant differences in mean vertical bone resorption (2.45 mm versus 0.68 mm at 4 months) concluding that the process of bone modeling and remodeling differs significantly between the two models (Botticelli et al. 2006).

Recent modifications of the implant surface topography at the nano-scale level have provided further evidence of enhanced bone response in both, animal experiments (Meirelles et al. 2008) and human biopsy material (Orsini et al. 2007).

We, however, lack precise knowledge on the critical factors that may affect the early healing of implants placed in fresh extraction sockets. Thus, the purpose of this study was to describe the dimensional changes of the buccal walls of fresh extraction sockets following implant installation in a dog model studying the influence that the socket dimensions and a calcium-phosphate nano treated surface (DCD nanoparticles™, Biomet 3i) may play on the histological outcome.

Materials and Methods

16 female Beagle dogs were included and divided into five groups according to the following healing intervals: 4 hours, 1, 2, 4 and 8 weeks. Each group included 3 dogs, except group 5 (8 weeks) that included 4. Four cylindrical screw shaped 3.25 mm diameter implants with lengths varying from 8.5 to 11.5 mm (Miniplant, Osseotite Certain, Biomet 3i) were placed in each dog. Test (DCD nanoparticles™, Biomet 3i) and control (Osseotite®, Biomet 3i) implants were randomly inserted into the distal sockets of the two rooted mandibular premolars 3P3 and 4P4 thus providing 4 study sites per dog.

Surgery

Mucoperiostal full thickness flaps were reflected on both sides of the mandibles to disclose the marginal aspect of the ridge in order to facilitate tooth extraction. After the atraumatic extraction of 3P3 and 4P4, the distal sockets of each premolar were selected as study sites while the mesial sockets were allowed to heal without intervention.

Osteotomy preparations were made into the sockets to the appropriate diameter ensuring that the implant shoulder was placed at the level of the marginal portion of the buccal plate. The healing abutments were secured and the flaps were repositioned and sutured with 4-0 vicryl resorbable sutures.

Biopsies and histological processing

Animals were sacrificed with an overdose of sodium-pentothal and perfused with a fixative solution through the carotid arteries. Block biopsies containing the implant and the surrounding peri-implant tissues were obtained using a diamond saw. Central buccal-lingual sections were prepared with a sawing and grinding technique.

Histometric evaluation

The histometric evaluation was carried out in a Leitz DM-RBE microscope (Leica, Heidelberg Germany) equipped with an image analysis software (Q-500 MC; Leica, Heidelberg, Germany). Four bucco-lingual sections per animal were examined and the following landmarks were identified on the buccal and lingual side of the sections:
shoulder of the implant. (I);
marginal bone crest (Bc);
most coronal bone to implant contact (B).
The following distances were calculated on the buccal and lingual aspects and expressed in mm:

- I-Bc
- I-B
- Bc-B

Since the bucco-lingual and mesio-distal dimensions of the two sockets were different, being wider the more distal, histometric mean measurements of the three outcome variables were also stratified by socket/site location (3P3 and 4P4), thus assessing whether a wider gap between the implant surface and the bony walls had any influence on the histological outcome.

Data analysis

The dog was used as the statistical unit of analysis. For each variable a mean value for each animal and healing interval was calculated and used for the data analysis. Histological results were expressed as mean linear distances of buccal and lingual measurements (± SD). Comparisons among the different healing periods/groups were analyzed using the one-way Anova combined with the Bonferroni post hoc test. Differences were considered statistically significant when p was <0.05. The statistical analysis was performed using the software Prism 5.0 (GraphPad, US).
Furthermore, at each healing interval, a mean value of each variable was calculated for test and control implants. Similarly, results were compared after stratifying according to socket site (3P3 and 4P4). Due to the limited number of animals per group, no statistical analysis was performed on such stratified data.

Results

Histometric analysis

The results from the histometric measurements (mm) assessed at the buccal

aspects of all 64 sections are depicted in tables I, II and III respectively.

I-Bc. There was a marked difference in the healing pattern between buccal and lingual alveolar walls. While there was an overall mean vertical difference of the buccal socket wall averaging 0.6 mm between day 0 and 8 weeks, such a difference was not observed at the lingual wall. The vertical buccal bone loss occurred mainly from baseline to one week (0.7mm). From 1 week till the end of the study, the buccal bone crest remained at the same level (0.6 mm apical of the implant shoulder). The differences between baseline (4 hours) and 1, 2, 4 and 8 weeks were statistically significant (Table I).

*Table 1. Results from mean (SD) histometric measurements of I-Bc distance (mm). I. Implant shoulder. Bc. Marginal bone crest. DAE. Osseotite® surface, Biomet 3i. DCD. Nanotite ™ surface, Biomet 3i. * Buccal measurements*

I-Bc	Buccal	Lingual	DAE*	DCD*	3P3*	4P4*
4 hours	-0,07 (0,07)	-0,73 (0,24)	-0,03 (0,01)	- 0,11 (0,25)	0,08 (0,19)	-0,22 (0,10)
1 week	0,73 (0,80)	-0,60 (0,16)	1,82 (2,96)	0,58 (1,25)	1,33 (1,90)	0,10 (0,28)
2 weeks	0,77 (0,35)	-0,71 (0,31)	0,65 (0,49)	0,82 (0,89)	1,11 (0,68)	0,28 (0,28)
4 weeks	0,70 (0,24)	-0,25 (0,46)	0,62 (0,20)	0,67 (0,57)	0,97 (0,32)	0,33 (0,11)
8 weeks	0,73 (0,28)	-0,63 (0,18)	0,94 (0,66)	0,24 (0,46)	1,13 (0,55)	0,30 (0,53)

When implants were stratified according to their different surface topography, sites that contained implants with DCD nano-particles surface exhibited less buccal bone resorption than the control sites at 8 weeks. Similarly, when implants were stratified according to their socket location, differences between the third (3P3) and the fourth (4P4) premolar site were observed. At the distal socket of the third premolar an overall vertical mean difference of 1.1 mm (0.5) was observed between day 0 and 8 weeks. The corresponding value for the fourth premolar site was 0.3 mm (0.5). In both types of sockets, the total amount of vertical bone resorption occurred between baseline and one week (Table I).

I-B. At baseline, the distance between the implant shoulder and the bone to implant contact was 2.5 (1.5) and 3.6 (3.2) mm at the buccal and lingual walls, respectively. From 4 hours to one week there were almost no changes, while between 1 and 2 weeks, 50% of the changes occurred, mostly at the lingual wall, where these changes were statistically significant ($P<0.05$). At the end of the study, I-B measured almost the same at both sides (1.3 mm) (Table II).

Table II depicts the results from the I-B measurements when stratified by socket location. The first bone to implant contact at the fourth premolar site was located more apically than at the third premolar site. At the distal socket of the third premolar (3P3) a marked vertical bone resorption was observed with the I-B distance

dropping from 1.3 (0.7) at day 0 to 3.2 (2.7) mm at 1 week. The I-B distance then rebounded to baseline values at 8 weeks (1.2 (0.5) mm). Conversely, at the distal socket of the fourth premolar (4P4), the distance I-B consistently diminished, from 3.6 (1) at 4 hours to 2 (1.3) mm at one week and then continued to 1.4 (0.5) mm at 8 weeks (Table II).

*Table 2. Results from mean (SD) histometric measurements of I-B distance (mm). I. Implant shoulder. B. Most coronal bone to implant contact. DAE. Osseotite® surface, Biomet 3i. DCD. Nanotite ™ surface, Biomet 3i. * Buccal measurements*

Bc-B	Buccal	Lingual	DAE*	DCD*	3P3*	4P4*
4 hours	2,54 (0,67)	4,39 (1,75)	2,24 (1,77)	2,84 (1,68)	1,21 (0,76)	3,87 (1,17)
1 week	1,65 (0,95)	3,55 (1,70)	0,83 (0,90)	2,05 (1,09)	0,89 (0,60)	1,99 (1,34)
2 weeks	1,09 (0,46)	2,20 (2,28)	0,91 (1,18)	1,21 (1,14)	0,49 (0,54)	1,72 (1,31)
4 weeks	0,67 (0,24)	0,70 (0,32)	0,47 (0,46)	0,76 (0,38)	0,32 (0,37)	0,92 (0,23)
8 weeks	0,63 (0,27)	1,84 (0,19)	0,39 (0,32)	1,10 (0,94)	0,10 (0,11)	1,10 (0,66)

BC-B. The distance between the bone crest and the most coronal bone to implant contact represented the infrabony component measured at the buccal and lingual aspects of the implant. At baseline, this distance was higher at the buccal side. Although this distance diminished at each time interval, still at 8 weeks, the infrabony component measured 0.8 (0.7) at the buccal and 1.8 (0.9) mm at the lingual aspect, respectively (table III).

When comparing implants according to their socket location, marked differences between the third and the fourth premolar sites were observed. At baseline the infrabony component was 1.2 (0.8) and 3.9 (1.1) mm, at the 3rd and 4th premolars, respectively. From 4 hours until the end of the study the BC-B distance was reduced mainly at the fourth premolar site. After 8 weeks of healing the distance between the bone crest and the most coronal bone to implant contact was approximately 0 and 1 mm at the third and fourth premolars, respectively (Table III).

Discussion

This investigation evaluated the early dimensional changes (from 4 hours to 2 months) of the buccal and lingual crests after placing implants into fresh extraction sockets. Furthermore, we aimed to assess whether the socket dimension as well as a new surface nano-topography (DCD nano-particles™, Biomet 3i) influenced the crest healing dynamics.

In the present animal experiment the overall mean resorption of the vestibular plate

*Table 3. Results from mean (SD) histometric measurements of Bc-B distance (mm). Bc. Margina bone crest. B. Most coronal bone to implant contact. DAE. Osseotite® surface, Biomet 3i. DCD. Nanotite ™ surface, Biomet 3i. * Buccal measurements*

Bc-B	Buccal	Lingual	DAE*	DCD*	3P3*	4P4*
4 hours	2,54 (0,67)	4,39 (1,75)	2,24 (1,77)	2,84 (1,68)	1,21 (0,76)	3,87 (1,17)
1 week	1,65 (0,95)	3,55 (1,70)	0,83 (0,90)	2,05 (1,09)	0,89 (0,60)	1,99 (1,34)
2 weeks	1,09 (0,46)	2,20 (2,28)	0,91 (1,18)	1,21 (1,14)	0,49 (0,54)	1,72 (1,31)
4 weeks	0,67 (0,24)	0,70 (0,32)	0,47 (0,46)	0,76 (0,38)	0,32 (0,37)	0,92 (0,23)
8 weeks	0,63 (0,27)	1,84 (0,19)	0,39 (0,32)	1,10 (0,94)	0,10 (0,11)	1,10 (0,66)

amounted to 0.6 (0.7) mm 8 weeks after implant placement. This vertical resorption was not observed at the lingual wall. These findings are not consistent with data published by Araujo et al (2005). They observed bone resorption of approximately 2-2.5 mm at the buccal crest 3 months after implant placement. The different histological outcomes obtained in the current experiment, may be in part explained by the wider implant diameters and the longer healing period that was used in the study by Araujo. A recent study in the beagle dog (Blanco et al. 2008) comparing flapped versus flapless surgery used 3.3 mm wide implants into fresh extraction sockets of 3P3 and of 4P4. They reported about 1.33 and 0. 8 mm of resorption of the vestibular plate at the flapped and flapless groups, respectively. These results are in accordance with findings presented in the present experiment. The possible influence of the socket dimension on the ridge alterations was also addressed in the current study. While a minor vertical change (0.3mm) occurred between baseline and 8 weeks at the buccal plate at the fourth premolar sites, the corresponding change at the third premolar site was about 1mm. Furthermore, at the 3P3 sites, no vertical defects were present at the marginal bone/implant interface due to the pronounced resorption of the buccal plate, while at the fourth premolar sites the vertical infrabony component of the defect amounted to approximately 1-1.5 mm. The influence of a wider gap between the implant surface and the bone tissue in immediate implant placement following tooth extraction was investigated by Araujo et al. (2006b). They demonstrated that the wider the combined defect-bone wall dimensions, the less the reduction of bone to implant contact (Araujo et al. 2006). It is however unclear whether it is the thicker bone wall or the wider gap that is relevant in the prevention of the buccal crest resorption. In the present study another important difference to consider when evaluating the healing at the 3rd and 4th premolar sites is the presence of the first molar 1M1 distal to the fourth premolar site. The tooth and its attachment apparatus may have in part prevented the buccal plate resorption.

The influence of the implant surface nano-topography on the dimensional changes

of the crest was not possible to evaluate due to the limited number of animals in each healing group. Mean values indicated that less resorption of the buccal plate occurred at the test when compared to control implants, 8 weeks after placement. In conclusion results from the present investigation showed a moderate mean resorption of the buccal bone crest of 0.6 (0.7) mm at 2 months after implant placement. Most of the resorption occurred at the third premolar site during the first week of healing. In sites with thick bone walls and with a gap between the implant surface and the bone wall, the risk of bone resorption was lower. These findings confirm results from clinical studies that showed that this surgical protocol of placing implants into fresh extraction sockets does not provide a predictable outcome (Evans & Chen 2008). More experimental and clinical studies are needed to further understand risk factors involved in the outcomes after implant placement into fresh extraction sockets.

Acknowledgements

This study was partially sponsored by a research grant from Biomet 3i.

References

– Anneroth, G., Hedstrom, K.G., Kjellman, O., Kondell, P.A. & Nordenram, A. (1985) Endosseus titanium implants in extraction sockets. An experimental study in monkeys. Int J Oral Surg 14, 50-54.

– Araujo, M.G., Sukekava, F., Wennstrom, J.L. & Lindhe, J. (2005) Ridge alterations following implant placement in fresh extraction sockets: an experimental study in the dog. J Clin Periodontol 32, 645-652.

– Araujo, M.G., Wennstrom, J.L. & Lindhe, J. (2006) Modeling of the buccal and lingual bone walls of fresh extraction sites following implant installation. Clin Oral Implants Res 17, 606-614.

– Blanco, J., Nunez, V., Aracil, L., Munoz, F. & Ramos, I. (2008) Ridge alterations following immediate implant placement in the dog: flap versus flapless surgery. J Clin Periodontol 35, 640-648.

– Botticelli, D., Persson, L.G., Lindhe, J. & Berglundh, T. (2006) Bone tissue formation adjacent to implants placed in fresh extraction sockets: an experimental study in dogs. Clin Oral Implants Res 17, 351-358.

– Evans, C.D. & Chen, S.T. (2008) Esthetic outcomes of immediate implant placements. Clin Oral Implants Res 19, 73-80.

– Meirelles, L., Arvidsson, A., Andersson, M., Kjellin, P., Albrektsson, T. & Wennerberg, A. (2008) Nano hydroxyapatite structures influence early bone formation. J Biomed Mater Res A.

Orsini, G., Piattelli, M., Scarano, A., Petrone, G., Kenealy, J., Piattelli, A. & Caputi, S. (2007) Randomized, controlled histologic and histomorphometric evaluation of implants with nanometer-scale calcium phosphate added to the dual acid-etched surface in the human posterior maxilla. J Periodontol 78, 209-218.

– Paolantonio, M., Dolci, M., Scarano, A., d'Archivio, D., di Placido, G., Tumini, V. & Piattelli, A. (2001) Immediate implantation in fresh extraction sockets. A controlled clinical and histological study in man. J Periodontol 72, 1560-1571.

– Schwartz-Arad, D., Laviv, A. & Levin, L. (2007) Survival of immediately provisionalized dental implants placed immediately into fresh extraction sockets. J Periodontol 78, 219-223.

XIV CONGRESSO INTERNAZIONALE