Histological Study of Bone Quality in the Implant Sites Prepared by the Drilling and Expansion Techniques

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Introduction: Bone drilling and expansion techniques have been used for implant site preparation. However, histological studies comparing these two techniques are limited. This study aimed to histologically assess the bone quality in the implant sites prepared by the bone drilling and expansion techniques in a sheep model. **Materials and Methods:** This experimental animal study was conducted on three sheep and four sites were chosen in their mandibles. Implant holes were created by bone drilling and expansion techniques in an alternate fashion. The first sheep underwent vital perfusion immediately after surgery and its mandible was fixed. The second and the third sheep were subjected to vital perfusion 19 and 26 days after surgery, respectively. The collected samples were stained with hematoxylin and eosin and the percentage of osteogenesis, the amount of ossification and sequester area, were measured by computer assisted histomorphometric analysis system. The amount of inflammation was estimated for each sample, considering the frequency of inflammatory cells infiltration, in terms of degree of inflammation as zero, less than 10% and more than 10%, under x400 magnification. **Results:** No significant difference was noted between the drilling and expansion techniques for implant site preparation in terms of degree of inflammation or rate of osteogenesis. The amount of sequesters was different between the two groups in the first days after surgery but no significant difference was noted in this regard between the two groups after 3 weeks. **Conclusion:** According to the histological evaluation, the method of implant sites preparation does not effect of quality of bone regeneration.

Keywords: Dental Implant; Drilling; Expansion; Osteotome

Introduction

Several methods are currently employed for preparation of dental implant site such as bone drilling and bone expansion using dental osteotoms. Dental osteotoms laterally compact the bone and decrease heat generation during drilling and increase the primary stability of implants (1). The primary stability of implant plays a critical role in its long-term success (2, 3). The main advantage of bone expansion is its lower invasiveness compared to bone drilling. In bone expansion, the medullary bone is compressed against the cortical wall to expand the buccal wall. Clinical studies have demonstrated that the bone expansion technique has a higher success rate in the maxilla compared with the mandible (4). Many studies have evaluated the effect of different implant placement techniques on the success of osseointegration. However, studies comparing the bone expansion and drilling techniques in terms of histological changes and traumatization of bone are limited. This is important because traumatization of bone cells during implant site preparation can alter the bone quality and compromise the implant success. Cell damage can compromise the healing process. Also, it can increase the rate of bone loss. In some cases, the bone expansion technique may be able to increase the width of a narrow ridge and eliminate the need for bone grafting and augmentation, which are costly for patients (5-7). This study aimed to histologically compare the effects of bone drilling and bone expansion by osteotome on the socket walls in the mandibular bone of the sheep model.

Materials and Methods

Animal study

This study was done on 12 surgical sites in three Bakhtiarian sheep weighing approximately 55±2 kg. The study was conducted in accordance with the Guidelines for Ethical

Table 1. Frequency of degree of inflammation in the drilling and expansion groups

Degree of inflammation	Drilling	Expansion
0%	16.7%	16.7%
<10%	25%	25%
10%>	8.3%	8.3%
total	50%	50%

Table 2. Amount of sequesters in the drilling and expansion groups (n=6)

Variable	Group	Mean (SD)
Osteogenesis	Drilling	16.97 (14.56)
	Expansion	14.28 (13.76)
Sequestration	Drilling	5.01 (8.37)
	Expansion	7.7 (10.2)
Inflammation	Drilling	50%
	Expansion	50%

Table 3. Rate of osteogenesis in the drilling and expansion groups

Time point	Drilling	Expansion
Day 0	0	0
Day 19	22.22±9.59	20.33±18.19
Day 26	28.96±7.96	22.52±0.28
P-value	0.056	0.2

Table 4. Amount of bone sequesters in the drilling and expansion groups

Time point	drill	expand
Day 0	15.05±6.99	19.99±6.25
Day 19	0	3.12±4.41
Day 26	0	0
P-value	0.052	0.03

Conduct in Care and Use of Animals and approved by Ethical committee of Shahid Beheshti University of Medical sciences. The sheep were accommodated to the animal room of Tehran University of Medical Sciences, School of Veterinary Medicine three days prior to the surgical procedure. The sheep remained NPO for 24 hours prior to the surgical procedure. They were also refrained from drinking water for 6 hours prior to the procedure. The sheep were sedated by intravenous administration of 2% xylazine (0.5 mg/kg). After stabilization, a #17 catheter was inserted into the left jugular vein and anesthesia was induced by administration of 5 mg/kg ketamine. The sheep were under constant monitoring during anesthesia. After anesthesia induction, the oral cavity was first rinsed with saline and betadine and then with 2% chlorhexidine (Najo, Iran). The area was prepped and draped. The mouth remained open using a retractor and an incision was made at the midline of the mandibular alveolar ridge. A flap was elevated and implant holes were created at the designated sites by the drilling and expansion techniques in an alternate fashion. It should be noted that an edentulous area exists between the anterior and posterior teeth of sheep measuring 10 cm in length. This area was chosen as the site of implant placement in our study. In this region, four holes were drilled with a drill with 2.2 mm diameter starting from the posterior towards the anterior region. The first hole in the posterior region was prepared using 2.5 and 3 mm bone expanders. Next, the second hole from the back was prepared using 2.75 and 3 mm drills. The third hole from the back was prepared using 2.5 and 3 mm bone expanders. The fourth hole from the back was prepared with 2.75 and 3 mm drills (Figures 1 and 2). The area was then thoroughly rinsed with saline and sutured. It should be noted that expanding the holes in the posterior region was more difficult compared to the more anterior holes.

Next, the first sheep was subjected to vital perfusion. The second and third sheep underwent the same procedures as explained for the first sheep with the difference that the second and third sheep underwent vital perfusion 19 and 27 days after the surgical procedure, respectively. After vital perfusion, a sample was obtained from the area with callus for histomorphometric assessment.

Microscopic evaluation of healing at the surgical site

The samples were immersed in 10% buffered formalin for fixation and coded. After 4 days, decalcification was performed using 10% formic acid for 3 weeks. The tissue samples were then processed, which included dehydration, clearing, alcohol removal and embedding in paraffin. Longitudinal sections were then made at the sample cross-section; slides were prepared and stained with hematoxylin and eosin. The sections included the entire surface of the holes. The samples were then inspected under a light microscope at 40×, 100× and 200× magnifications by a pathologist blinded to the group allocation of samples. The pathologist histologically scored the samples considering the frequency of inflammatory cells infiltration in terms of degree of inflammation as zero, less than 10% and more than 10% under 400× magnification. Type of connective tissue *ie.*, granulation tissue, fibrous, the amount of sequesters and rate of osteogenesis *ie.*, the percentage of new bone formation, were also evaluated and recorded. For assessment of the rate of osteogenesis and the amount of sequesters, digital images were captured using a digital camera (E840, Nikon, Japan) at 40× magnification and the amount of ossification and sequester area were measured using computer assisted histomorphometric analysis system (Iranian histomorphometric analysis software-IHMM software, ver. 1, SBMU, Iran.)

Statistical Analysis

Student T test used for pairwise comparison. Significant difference was considers at (P>0.05).

Figure 1. Drilling a hole

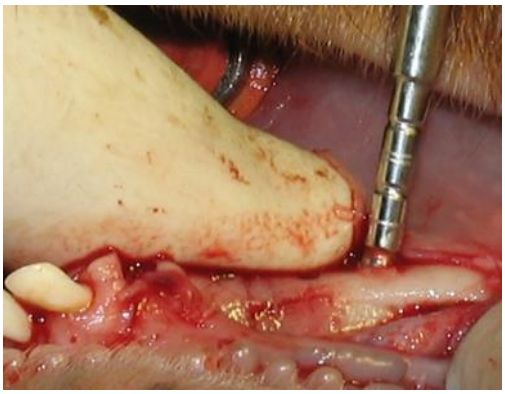

Figure 2. Expanding a hole

Results

The rate of inflammation in all samples was compared between the drilling and expansion methods at all time points. The frequency of zero degree of inflammation was the same for both groups of drilling and expansion (16.7%). The frequency of less than 10% inflammation was the same in the drilling and expansion groups and was equal to 25%. The frequency of rate of inflammation >10% was the same in both the drilling and expansion groups and was equal to 8.3%. No significant difference was noted between the two groups in degree of inflammation (Table 1).

The rate of osteogenesis (new bone formation) was the same on days 0. 19 and 26 in the drilling group (16.97±14.56) and in the expansion group (14.28±13.76); the difference in this regard was not significant between the two groups (P>0.05).

The amount of sequesters was the same on days 0. 19 and 26 in the drilling group (5.01±8.37) and in the expansion group (7.70±10.20); the difference in this regard was not significant between the two groups (P>0.05, Table 2).

The rate of osteogenesis on day zero was zero in both the drilling and expansion groups. The rate of osteogenesis was 22.22% in the drilling and 20.33% in the expansion group on day 19. These values were 28.69% and 22.52%, respectively on day 26. The difference in rate of osteogenesis at different time points was not significant in the drilling (P>0.05) or expansion (P>0.05) groups (Table 3).

The amount of bone sequesters was 15.05% in the drilling and 19.99% in the expansion group on day zero. These values were 0 and 3.12, respectively on day 19 and zero for both groups on day 26. The difference in the amount of sequesters at different time points was not significant in the drilling group (P<0.05), while it was significant in the expansion group (P<0.05, Table 4).

Discussion

Lateral compaction of bone increases the cancellous bone density and creates a standard controlled inflammation (8). The success rate of bone expansion depends on preservation of the labial wall, in order to firmly maintain the periosteum which provides 80% of blood supply to the area (9). The high success rate of expansion in narrow ridges is due to the fact that it allows manipulation of cortical bone without cutting the periosteal attachments (10). In this study, we measured the rate of osteogenesis, the amount of sequesters, and the degree of inflammation at the surgical site on 0, 19 and 26 days after the procedure. The rate of osteogenesis, the amount of sequesters and the degree of inflammation were compared between the two methods and at different time points.

Nikenke *et al.* (11) compared the bone-implant contact between the drilling and expansion methods at 2, 4 and 8 weeks and concluded that the bone-implant contact in the expansion technique was higher than that in the drilling technique; however, this difference was not significant in long-term. They concluded that the expanding technique increases new bone formation and enhances osseointegration in trabecular bone. Although we did not assess the bone-implant contact, the rate of osteogenesis was higher in the drilling group at 19 and 26 days. This difference between the results of the two studies may be due to fact that different type of bone used. We used sheep mandible in our study, which is mostly cortical; however, no significant difference existed between the two methods in long-term.

Bachter *et al.* (12) evaluated the implant stability and osseointegration between the expanding and drilling techniques in the tibia of Guinea pigs and concluded that reduction of implant stability by the use of expanding technique is due to the presence of microfractures in peri-implant bone. Blanco *et al.* (13) compared bone density around the implant holes created in the

maxillary tuberosity of human cadavers using the expanding and drilling techniques and concluded that the overall density of bone around the implant holes prepared by the expanding technique was significantly higher .(39.38±9.67 versus 31.06±5.9). Wux *et al.* (14) histologically compared the drilling and no drilling techniques for implant hole preparation at the buccal area of the maxilla in a canine model at 2, 4 and 8 weeks. They noticed the bone remodeling and new bone formation in both groups. The removal torque and bone-implant contact were significantly greater in no drilling group at 2 and 4 weeks. However, no significant difference was noted after 8 weeks between the two groups. They concluded that no drilling technique confers higher implant stability than the drilling technique.

In a clinical study, Shayesteh *et al.* (15) evaluated crestal bone loss and implant stability. The results of radiofrequency analysis showed significantly higher primary stability following implant insertion in the osteotome technique compared to the drilling technique. However, the two groups were not significantly different in this respect at three months, postoperatively. At 3th month, the osteotome group showed significantly higher bone loss than the drilling group. They concluded that the osteotome technique yields higher primary stability than the drilling technique; however, the osteotome technique has no superiority over the drilling technique after 3 months.

in a clinical study done by Padmanabhan *et al.*, (1) the crestal bone resorption and bone loss around dental implants were evaluated. they observed optimal implant stability in the drilling compared to the expanding group immediately after surgery. However, no significant difference was noted between the two groups after 180 days. Crestal bone loss was significantly lower in the drilling group at 180 days. They concluded that the osteotome technique is not suitable for routine implant placement compared to the drilling technique.

Based on the results, the bone-implant contact is higher up to 8 weeks postoperatively in the expanding technique. However, the difference in this respect is no longer significant after 8 weeks (11, 14). Also, the majority of relevant studies reported bone loss in the expanding technique after 2 months compared to the drilling technique (1, 4, 15). Butcher (12) and Cehreli (16) observed higher stability in the drilling compared to the expansion technique up to day 28. However, Shayesteh *et al.* reported higher stability in the expansion group up to day 28 compared to the drilling group. In a review study by Shalabi *et al.* (17), they found no significant difference between the two techniques. In general, studies have shown the superiority of expanding technique to the drilling technique in short-term *ie.*, 1 and 2 months, postoperatively, and have reported higher rate of osteogenesis in the first weeks in the expanding technique. However, after 4 weeks, new bone formation is not significantly different between the two techniques. Our study did not show any significant difference in terms of inflammation or new bone formation between the two techniques. The amount of sequesters was different in the two groups in the first days but this difference was no longer significant after 3 weeks.

The majority of previous studies used cancellous bone and evaluated bone-implant contact, implant stability and bone loss. However, we used sheep mandible which has a lower portion of cancellous and higher portion of cortical bone, which may explain the difference in the outcomes. Nonetheless, it may be concluded that the expanding technique can be used in cases where the ridge is narrow and sufficient bone for drilling does not exist.

Conclusion

The results showed that the osteotome technique had no significant difference with the drilling technique in terms of percentage of osteogenesis, degree of inflammation and the amount of sequesters.

Conflict of Interest: 'None declared'.

References

1. Padmanabhan TV, Gupta RK. Comparison of crestal bone loss and implant stability among the implants placed with conventional procedure and using osteotome technique: a clinical study. Journal of Oral Implantology. 2010;36(6):475-83.
2. Adell R, Lekholm U, Rockler B, Brånemark P-I. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. International journal of oral surgery. 1981;10(6):387-416.
3. Albrektsson T, Brånemark P-I, Hansson H-A, Lindström J. Osseointegrated titanium implants: requirements for ensuring a long-lasting, direct bone-to-implant anchorage in man. Acta Orthopaedica Scandinavica. 1981;52(2):155-70.
4. Nishioka RS, Souza FA. Bone spreader technique: a preliminary 3-year study. Journal of Oral Implantology. 2009;35(6):289-94.
5. Davarpanah M, Martinez H, Tecucianu J-F, Hage G, Lazzara R. The modified osteotome technique. International Journal of Periodontics & Restorative Dentistry. 2001;21(6).
6. Summers RB. A new concept in maxillary implant surgery: the osteotome technique. Compendium (Newtown, Pa). 1994;15(2):152, 4-6, 8 passim; quiz 62.
7. Pourdanesh F, Jafarian M, Shariati M, Sharifi D, Khojasteh A. Scanning Electron Microscope Evaluation of Dental Implant Socket

Hole: Drilling Versus Osteotome Technique. Journal of Craniofacial Surgery. 2016;27(5):e497-e500.
8. Nishioka RS, Souza FÁ. Bone spreading and standardized dilation of horizontally resorbed bone: technical considerations. Implant dentistry. 2009;18(2):119-25.
9. Chanavaz M. Maxillary sinus: anatomy, physiology, surgery, and bone grafting related to implantology--eleven years of surgical experience (1979-1990). The Journal of oral implantology. 1990;16(3):199-209.
10. Borgner RA, Kirkos LT, Gougaloff R, Cullen MT, Delk PL. Computerized tomography scan interpretation of a bone expansion technique. Journal of Oral Implantology. 1999;25(2):102-8.
11. Nkenke E, Kloss F, Wiltfang J, Schultze-Mosgau S, Radespiel-Tröger M, Loos K, *et al.* Histomorphometric and fluorescence microscopic analysis of bone remodelling after installation of implants using an osteotome technique. Clinical oral implants research. 2002;13(6):595-602.
12. Büchter A, Kleinheinz J, Wiesmann HP, Kersken J, Nienkemper M, Weyhrother Hv, *et al.* Biological and biomechanical evaluation of bone remodelling and implant stability after using an osteotome technique. Clinical oral implants research. 2005;16(1):1-8.
13. Blanco J, Suárez J, Novio S, Villaverde G, Ramos I, Segade LAG. Histomorphometric assessment in human cadavers of the peri-implant bone density in maxillary tuberosity following implant placement using osteotome and conventional techniques. Clinical oral implants research. 2008;19(5):505-10.
14. Marin C, Granato R, Suzuki M, Janal MN, Gil JN, Nemcovsky C, *et al.* Biomechanical and histomorphometric analysis of etched and non-etched resorbable blasting media processed implant surfaces: an experimental study in dogs. Journal of the mechanical behavior of biomedical materials. 2010;3(5):382-91.
15. Shayesteh YS, Khojasteh A, Siadat H, Monzavi A, Bassir SH, Hossaini M, *et al.* A comparative study of crestal bone loss and implant stability between osteotome and conventional implant insertion techniques: a randomized controlled clinical trial study. Clinical implant dentistry and related research. 2013;15(3):350-7.
16. Çehreli MC, Kökat AM, Comert A, Akkocaoğlu M, Tekdemir I, Akça K. Implant stability and bone density: assessment of correlation in fresh cadavers using conventional and osteotome implant sockets. Clinical oral implants research. 2009;20(10):1163-9.
17. Shalabi MM, Manders P, Mulder J, Jansen JA, Creugers NH. A meta-analysis of clinical studies to estimate the 4.5-year survival rate of implants placed with the osteotome technique. International Journal of Oral & Maxillofacial Implants. 2007;22(1).

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