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Osseointegration of dental implants without primary stability: an experimental study in sheep

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Abstract

Background and objective: Primary implant stability is considered necessary for achieving and maintaining osseointegration. This experimental study aimed to evaluate the outcome of implants without primary stability, clinically and radiographically.

Methods: Two adult sheep (3-4 years of age), 70 kg in weight, were included in the study. After sedation and local anesthesia, the lateral side of the basal bone of mandible is exposed by a single long incision. The implant bed performed in the inferior border of the basal bone of mandible drilling to 5 mm in diameter and 10 mm in length. Five implants were inserted into the basal bone of mandible for each side (right and left), but the sizes of inserted implant was 3.8 mm in diameter and 10 mm in length, after 4 months the 2 sheep were sacrificed and the universal torque ratchet was used to measure the stability of the implant by a counter torque 30 N/cm test. Cone Beam Tomography (CBCT) was used to evaluate the implants radiographically.

Results: Nineteen (from 20) implants successfully tolerated a 30 N/cm countertorque test comprising (95%). Only one implant failed to osseointegrate (5%). During the healing period, no any adverse clinical signs reported.

Conclusion: Dental implants may have a chance to osseointegrate even in the lack of primary stability.

Keywords: Dental implant, Osseointegration, Primary stability.

Introduction

Primary implant stability is a prerequisite for achieving and maintaining osseointegration.[1–3] Primary stability is defined as the absence of mobility in the bone bed after the implant has been placed.[4] There are basic principles to achieve successful osseointegration which includes: the use of biocompatible materials, an implant that precisely adapted to prepared bone (high primary stability), a traumatic surgery to minimize tissue damage and undisturbed healing phase (delay loading).[5] With various advances in implant microtopographic surfaces and design, practitioners have been able to modify and change the original Brånemark protocol to a great extent.[6,7] Later on one of these principles of delay loading was changed, and now an immediate loading of dental implants become an established technique without affecting the osseointegration. Several studies have shown that single stage surgery with immediate placement of dental implants after extraction and immediate loading of implants has predictable and successful results comparable to those of the traditional 2-stage protocol.[8–12] Comprehensive reviews of in vivo studies have reported that micromotion at the bone -implant interface in the range of 50 to 150 µm may adversely affect osseointegration and remodeling at bone bone-implant interface.[6-9] A review of literature found no studies evaluating the fate of dental implants when placed without primary stability. Therefore, this experimental study aimed to evaluate the outcome of implants without primary stability, clinically and radiographically. The study could fill in gaps in knowledge about an important subject concerning dental implantology.

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Methods

Two adult sheep (3–4 years of age), 70 kg in weight, were included in the study. All surgical procedures were performed under intravenous sedation and local anesthesia at the veterinary theater (Ankawa Veterinary Center-Erbil-Iraq). The animal was first sedated using ketamine hydrochloride 3 mL/kg (Rotexmedica GMBH, Trittau, Germany) and xylazine (Rompun; Bayer AG, Leverkusen, Germany), and 0.2 mg/kg local anesthesia consisting of lidocaine 1:100,000 are administered in the surgical area (to the basal bone of mandible). The surgical area is shaved, washed, and disinfected with povidone-iodine (Betadine) (Figure 1). The lateral side of the basal bone of mandible is exposed by a single long incision followed by a separate elevation of the skin and the facial layers. The implant bed performed in the inferior border of the basal bone of mandible and according to the manufacturer's guidelines of implant system (Nucleoss Implants, Izmir, Turkey), drilling to 5 mm in diameter and 10 mm in length. Five implants were inserted into the basal bone of mandible for each side (right and left), but the sizes of inserted implant was 3.8 mm in diameter and 10 mm in length, the implants were submerged about 1 mm in the marginal ridge of prepared implant bed (the implants were placed without primary stability), then the cover screw was installed. The surgical site is sutured in a layering approach to avoid flap dehiscence, using resorbable polyglactin sutures (Vicryl 3/0; Ethicon, Sommerville, NJ, USA) and silk sutures (Ethikon, China) for skin layer. A single dose of antibiotic (Alamycin 20 mg/kg; Norbrook, Northamptonshire, United Kingdom) is administered postoperatively and the animal is fed a standard diet. After ten days the silk suture was removed. The animals were followed up for four months.

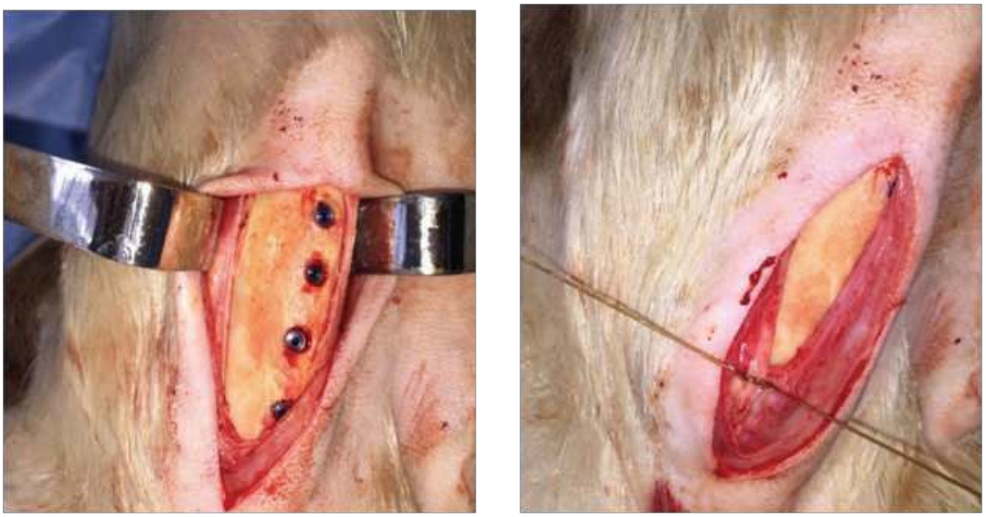

Figure 1: A. Implant placement in the inferior border of mandible. B. Suturing in layers.

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Results

After four months the two sheep were sacrificed and the mandible separated from the animal's skull and the implants were exposed because there was bone formation over the implants. The cover screw was removed from the implants and the universal torque ratchet is used to measure the stability of the implant by a counter torque 30 N/cm test was carried out (Figure 2). Cone Beam Tomography (CBCT) was used to evaluate the implants radiographically (Figure 3). Primary wound closure was obtained in all surgeries and no adverse effects were noted during the follow-up. At second stage procedure, no evidence of peri-implant marginal bone loss was observed clinically and 19 (from 20) implants successfully tolerated a 30 N/ cm countertorque test comprising (95%). Only one implant failed to osseointegrate (5%).

Figure 2: Universal torque ratchet is used to measure the stability of the implants (30 N/cm).

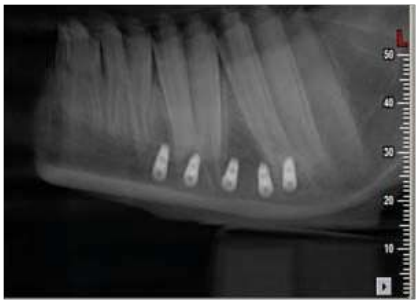

Figure 3: CBCT Showing the osseointegrated implants.

Figure 4: A. shows osseointegrated implants bone formation over the healing screw. B. the failed implant.

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Discussion

It has consistently been reported that primary stability is related to successful dental implant rehabilitation.[1-3] This study reported the use of 20 implants with no primary stability and loosely inserted in the implant bed. Many factors may play a role in implant osseointegration success. Lack of primary stability occurs when the mineralization of the bone is diminished, and the bone provides insufficient anchorage. A second clinical situation where lack of primary stability may result is the placement of an implant in an immediate extraction socket (a space larger than the implant itself). Inexperienced clinicians may either over prepare the osteotomy site, which strips the site or apply an unnecessary level of torque, breaking the bone around the implant. In our study, we placed all the implants in the basal bone of mandible. The data in this study agree with the observation that higher success rates are shown in the mandible than the maxilla.[14] Since the bone is often denser in the mandible than the maxilla, this data also supports other documented studies that have shown a connection between initial bone density and osseointegration rates.[15] Implant design refers to the three-dimensional structure of an implant with all the components and features that characterize it. It has been reported that the implant design is a vital parameter for attaining primary stability.[16] The texture of an implant's surface can influence the bone–implant interface. Studies have demonstrated a relationship between implant design and osseointegration.[17-19] Rough implant surfaces present a larger surface area and allow a firmer mechanical link to the surrounding tissues.[20] In this study, the used implants share good design and rough surface, and this also may attribute to the high rate of the success. Besides the quantity and quality of bone and morphology of the implant, the atraumatic surgical technique may also influence implant outcomes. Atraumtic surgery and the primary blood clot formation may play an important role in the healing process of dental implants. All the placed implants were in the inferior border (facing downward). There was a concern that the gravity force may mobilize and deliver the implants out of their bed. All the implants remained static in their place including the failed one. We believe that the primary blood clot played an important role in linking, fixing and osseointegration of the implants. Only one implant failed. This failure was the result of the surgical fault; the implant interfered with dental follicle of the molar tooth.

Conclusion

Dental implants may have a chance to osseointegrate even in the lack of primary stability. Future studies should be conducted with using more number of implants, studying the histology of bone to implant interface in such conditions.

Conflicts of interest

The authors report no conflicts of interest.

References

1. Brunski JB. In vivo bone response to biomechanical loading at the bone/dental-implant interface. Adv Dent Res 1999; 13:99–119.
2. Kim DG. Micromechanical Analysis of Bone at a Bone-Implant Interface. PhD Dissertation. Troy, NY: Rensselaer Polytechnic Institute; 2001.
3. Fazel A, Aalai S, Rismanchian M, Sadr-Eshkevari P. Micromotion and stress distribution of immediate loaded implants: A finite element analysis. Clin Implant Dent Relat Res 2009; 11:267–71.
4. Javed F and Romanos GE. The role of primary stability for successful immediate loading of dental implants: A literature review. J Dent 2010; 38:612–20.
5. Brånemark PI. Introduction to osseointegration. In: Brånemark PI, Janal MN, Coelho PG.editors. Tissue integrated prostheses. Chicago (IL): Quintessence Publishing Co. Inc; 1985: p. 29.
6. Ottoni JM, Oliveira ZF, Mansini R, Cabral AM. Correlation between placement torque and survival of single-tooth implants. Int J Oral Maxillofac Implants 2005; 20:769–76.
7. Irinakis T, Wiebe C. Initial torque stability of a new bone condensing dental implant. A cohort study of 140 consecutively placed implants. J Oral Implantol 2009; 35:277–82.

https://doi.org/10.15218/zjms.2017.011

8. Kawahara H, Kawahara D, Hayakawa M, Tamai Y, Kuremoto T, Matsuda S. Osseointegration under immediate loading: Biomechanical stresss train and bone formation-resorption. Implant Dent 2003; 12:61–8.
9. Freitas AC, Bonfante EA, Giro G, Janal MN, Coelho PG. The effect of implant design on insertion torque and immediate micromotion. Clin Oral Implants Res 2012; 23:113–8.
10. Ostman PO, Hellman M, Sennerby L. Direct implant loading in the edentulous maxilla using a bone density-adapted surgical protocol and primary implant stability criteria for inclusion. Clin Implant Dent Relat Res 2005; 7:60–9.
11. Hui E, Chow J, Li D, Liu J, Wat P, Law H. Immediate provisional for single-tooth implant replacement with Brånemark system: preliminary report. Clin Implant Dent Relat Res 2001; 3:79–86.
12. Li W, Chow J, Hui E, Lee PK, Chow R. Retrospective study on immediate functional loading of edentulous maxillas and mandibles with 690 implants, up to 71 months of follow-up. J Oral Maxillofac Surg 2009; 67:2653–62.
13. Esposito M, Hirsch JM, lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. Eur J Oral Sd 1998; 106:721–64.
14. Sennerby l, Roos J. Surgical determinants of clinical success of osseointegrated implants. Int J Prosthodont 1998; 11:408–20.
15. Chong L, Khocht A, Suzuki JB, Gaughan J. Effect of implant design on initial stability of tapered implants. J Oral Implantol 2009; 35:130–5.
16. Romanos GE, Johansson CB. Immediate loading with complete implant-supported restorations in an edentulous heavy smoker: Histologic and histomorphometric analyses. Int J Oral Maxillofac Implants 2005; 20:282–90.
17. Romanos GE, Toh CG, Siar CH, Wicht H, Yacoob H, Nentwig GH. Bone-implant interface around titanium implants under different loading conditions: a histomorphometrical analysis in the Macaca fascicularis monkey. J Periodontol 2003; 74:1483–90.
18. Delaunay CP, Kapandji AI. Acetabular screw rings and surface treatment. Clin Orthop Relat Res 1997; 340:130–41.
19. Davies JE. Mechanisms of endosseous integration. Int J Prosthodont 1998; 11:391–401.