Chapter 4

Osteotome-Assisted Lateral Bone Expansion and Condensation with Immediate Dental Implants Placements

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Dental Implants

Abstract

Osteotome-assisted lateral bone expansion and condensation with immediate dental implant placement is good for the purpose for which it was introduced, and its advantages include reduced surgical trauma and a shorter treatment time. Ridge expansion technique using osteotomes can be used to gradually expand the ridge by taking advantage of the slight increases in diameter of the osteotomes. This will improve the ridge topography by widening the osseous ridge as the larger diameter osteotomes are sequentially inserted into the osteotomy site opening created by the previous instrument. By using increasingly larger osteotomes the ridge can be expanded and allow for the placement of an adequate width implant. This chapter describes the use of osteotome assisted bone expansion of atrophic ridge in patients with narrow alveolar ridge width. Expansion of the bone would routinely occur labially, compensating for the original dimensional loss of bone, Thus, bone manipulation enables one to recontour the bone in the direction of its loss, place the implant in a position closer to that of the original tooth socket, and ultimately restore normal root morphology planned to support the restorative crown.

Introduction

Dento-alveolar bony defects are very common and poise a significant problem in dental treatment and rehabilitation. Reconstruction of dento-alveolar bony defects using minimally invasive techniques would greatly enhance the success and patient acceptance of this area of reconstructive surgery. Over the past three decades, great strides have been made in the field of alveolar bone preservation and augmentation. Reviews of the literature identify many techniques and materials that have been used successfully to obtain esthetically and functionally acceptable alveolar ridge for successful implant [1]. The alveolar ridge revealing knife-edge morphology or non space-maintaining defects usually requires a local alveolar ridge expansion procedure. In such situations the ridge may be expanded by splitting [2] or spreading [3, 4] of the bone, resulting in a sufficient width for implant bed preparation. Summers in 1994 modified this procedure by developing a special osteotome technique and a set of instruments [5]. The osteotome set consists of matched and tapered hand instruments which create implant sites by widening the ridge and condensing the bone in lateral and apical directions. The tapered osteotomes allow for minimal heat generation, greater tactile sensitivity, faster and larger bone apposition by compressing the bone laterally and thus creating a denser interface for the implant to be placed [6,7]. Several bone volume and defect classification systems have been proposed and developed. Characteristic bone volume changes after tooth loss were evaluated in the mandible by Atwood [8,9]. A maxillary alveolar process of resorption for mandible was presented by Misch in 2008 [10].

Dental Implants

Another classification was proposed by Cawood and Howell [11]. The dental implant approach to different volumes is more specific than the Atwood classification permits, and as such, several bone volume classifications for implant dentistry have been developed. Weiss and Judy developed a classification of mandibular atrophy and its influence on subperiosteal implant therapy in 1974 [12]. Louisiana State University and Kent presented a classification of alveolar ridge deficiency designed for alloplastic bone augmentation in 1982 [13]. Another classification was proposed by Zarb and Lekholm in 1985 for residual jaw morphology with the insertion of Branemark fixtures [14]. In 1985 Misch and Judy established four basic divisions of alveolar bone for implant dentistry in the maxilla and mandible, which follow the natural resorption phenomena represented by Atwood [15,16].

Alveolar ridge defects are classified according to their three-dimensional morphology form, severity, and extent [17]. A defect limited exclusively to the bucco-lingual direction with normal ridge height has been classified as a class I or class B defect. A bone loss running in the apico-coronal direction only was described as a class II or class A defect. The defect that exists in both axes, i.e., a combined vertical and horizontal defect, has been characterized as a class III or class C defect and has a combination bucco-lingual and apico-coronal resorption of alveolar bone resulting in loss of ridge height and width [18]. The extent of alveolar ridge defect considered mild if less than

4 mm, moderate when 3 to 6 mm, and extensive when greater than 6 mm [19]. Various bone augmentation techniques have been employed to reconstruct these different ridge defects. The predictability of the augmentation procedures depend on the horizontal and vertical extents of the defect.

Classification of Alveolar Ridge Defects

Alveolar ridge defects are classified according to their three-dimensional morphology form, severity, and extent [20].

I- A defect limited exclusively to the bucco-lingual direction with normal ridge height has been classified as a class I or class B defect.

II- A bone loss running in the apico-coronal direction only was described as a class II or class A defect.

III- The defect that exists in both axes, i.e., a combined vertical and horizontal defect, has been characterized as a class III or class C defect and has a combination bucco-lingual and apico-coronal resorption of alveolar bone resulting in loss of ridge height and width [21] (Figure 1).

The extent of alveolar ridge defect considered mild if less than 4 mm, moderate when 3 to 6 mm, and extensive when greater than 6 mm [22].

Dental Implants

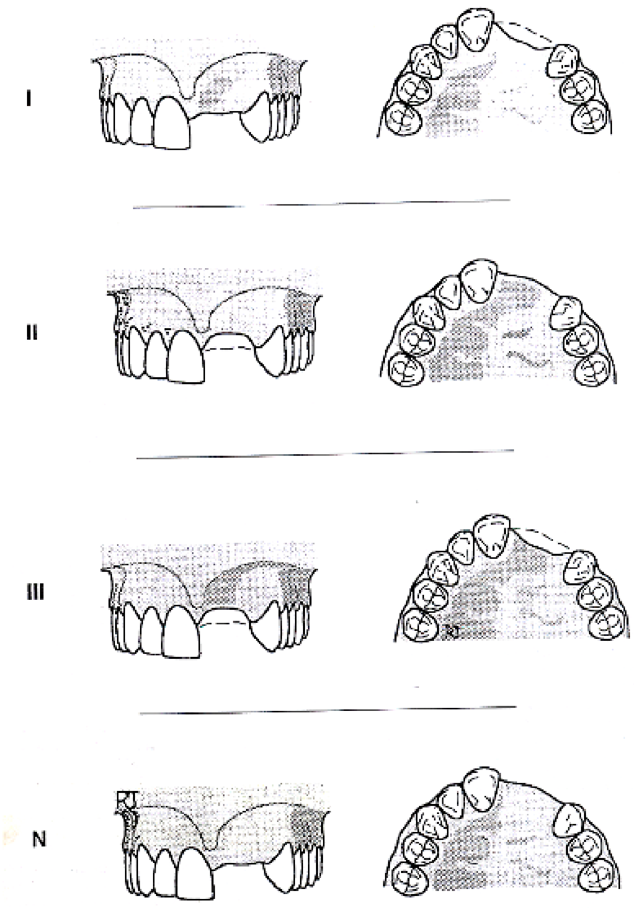


Figure 1: Classifications of alveolar ridge defects.

Classifications of Bone Density

Various classifications of bone density have been proposed in literature in order to simplify understanding (Figure 2):

- Misch CE described four bone densities found in the edentulous regions of the maxilla and the mandible based on macroscopic cortical and trabecular bone characteristics. D1 bone is primarily dense cortical bone, D2 bone has dense to thick porous cortical bone on the crest and coarse trabecular bone underneath, D3 bone has thinner porous cortical crest and fine trabecular bone within and D4 has almost no crestal cortical bone and fine trabecular bone composes almost all of the total volume of bone [23].
- Based on clinical hardness of bone as perceived during drilling prior to implant placement Misch CE categorized the bone density into four groups. Drilling and placing implants in D1 has the tactile analogue of oak or maple wood. D2 bone is similar to the tactile sensation of drilling into spruce or white pine wood. Drilling into D3 bone has the tactile analogue of balsa wood. D4 bone is similar to drilling into styrofoam [24].
- Misch CE, Kircos LT classified the bone density into five groups based on number of Hounsfield units (HU). D1 corresponds to values greater than 1250 HU, D2 has 850–1250 HU, D3 refers to density within 350–850 HU, D4 has 150–350 HU and D5 less than 150 HU [25]. D1 is primarily found in the anterior mandible, buccal shelf and midpalatal region. D2 is found primarily in the anterior maxilla, the midpalatal region and the posterior mandible. D3 is found primarily in the posterior maxilla and mandible. D4 is found primarily in the tuberosity region [26].

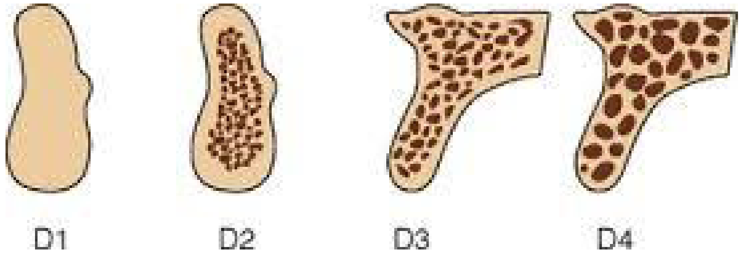


Figure 2: Classifications of bone density.

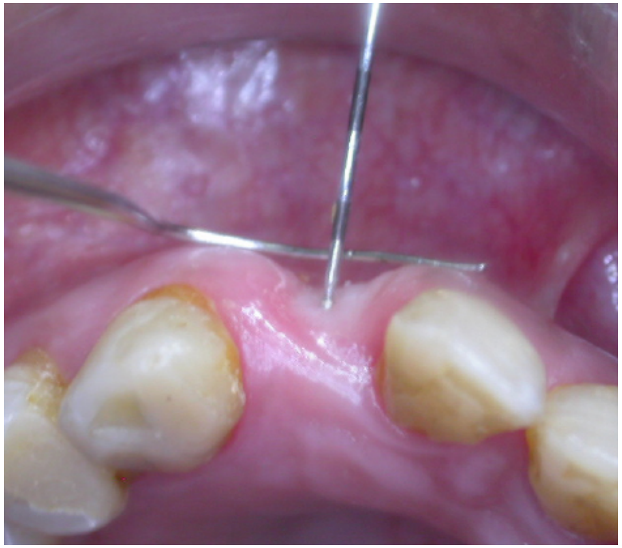
Pattern of Bone Loss

The alveolar bone loss is known to occur at a rapid rate during the first year after tooth extraction and may continue for years. Within the first year of the tooth loss there's a 25% decrease in the width of the crestal bone and a 40% decrease in the bone width occurs within the first 1-3 year after tooth extraction, resulting in a labial plate of bone that is located lingual of its original location

(Figure 3) and (Figure 4) [27]. Bone volume changes after tooth loss were evaluated in the mandible by Atwood. The posterior mandible resorbs at a rate approximately 4 times faster than the anterior mandible. Resultant narrow ridge is often inadequate for many 4 mm wide root form implants. Preservation or recontouring of the labial appearance of the alveolar process is one of the keys to optimal implant esthetics and a long-term result. To re-establish ridge architecture to sufficient height and width seems only natural before implant placement in the available edentulous ridge area, if the goal is to create biologically sound replicas of natural teeth meeting the demands of their original form and function [28].

3 (a)

3 (b)



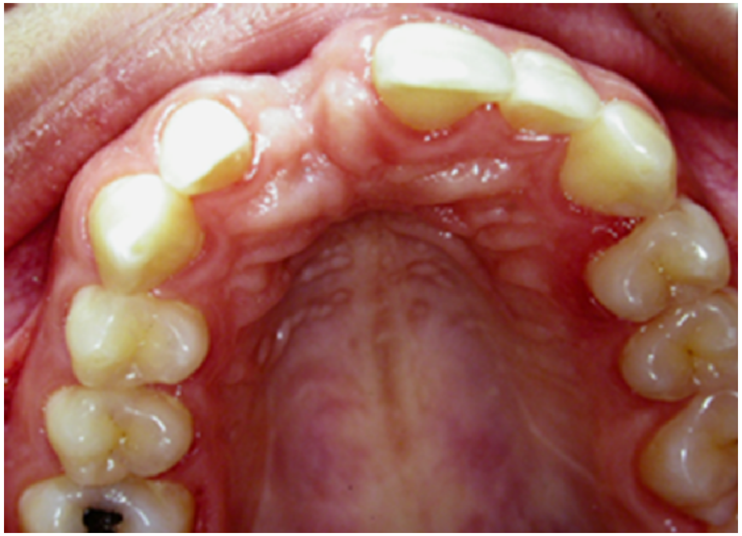
3 (c)

Figure 3: Defect limited exclusively to the bucco-lingual direction with concavity due to bone loss.

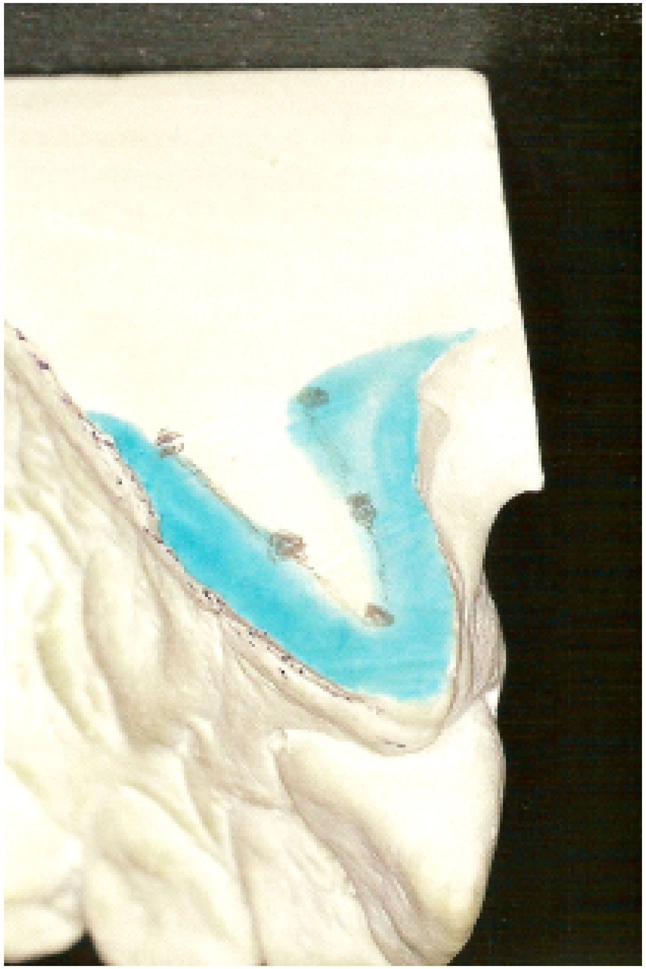
Dental Implants

Inadequate Ridge Width

Ridge width affects many of the parameters of the final restorations, which can easily be overlooked without careful preoperative planning. Edentulous alveolar ridges less than5 mm. wide require horizontal augmentation or horizontal expansion of the available bone for the placement of endosseous implants in order to produce the necessary quantity of bone of at least 1 mm around the implants and to guarantee long-term osseointegration (Figure 4).



4(a)



4(b)

Figure 4: Defect at the bucco-lingual direction with jaw mapping demonstrating the thickness of the bone and soft tissue (blue high light).

If the ridge width is not adequate following problems can occur:

- Leaving a thin labial bone plate at the time of implant placement can lead to exposure of the implant after the slightest of resorption.
- A labial dehiscence of bone may contribute to future implantitis or an unesthetic metal showing through the gingiva.
- Undercuts found on the labial alveolar bone, give rise to off-axis loads and a less than perfect emergence profile.

To overcome all these problems the deficient sites are either grafted or enhanced by different means. Numerous procedures have been devised to compensate for a deficient ridge width:

Various treatment options devised over the years [29] for Inadequate ridge width are:

1. Increase width by osteoplasty.
2. Utilize narrower diameter implants.
3. Increase width by augmentation [30].
4. Bone expansion.
5. Ridge splitting [31].
6. Horizontal distraction osteogenesis [32].

Lateral Bone Expansion

Definition

Bone expansion can be defined as the manipulation of the bone to form a receptor site for an implant without the removal of any bone from the patient [33]. Many people incorrectly believe that bone is hard and unbendable. However Living bone is much softer and can be stretched open, making the concept of bone expansion possible. Through serial use of graduated series of bone expansion devices with a cylindrical instruments and tapered tip and an appropriate diameter to widen the implant bed can be slowly expanded to increase their width (Figure 5).

Figure 5: Osteo-condensation with series of bone expansion devices with a cylindrical instruments and tapered tip and an appropriate diameter to widen the implant bed.

Bone Condensation

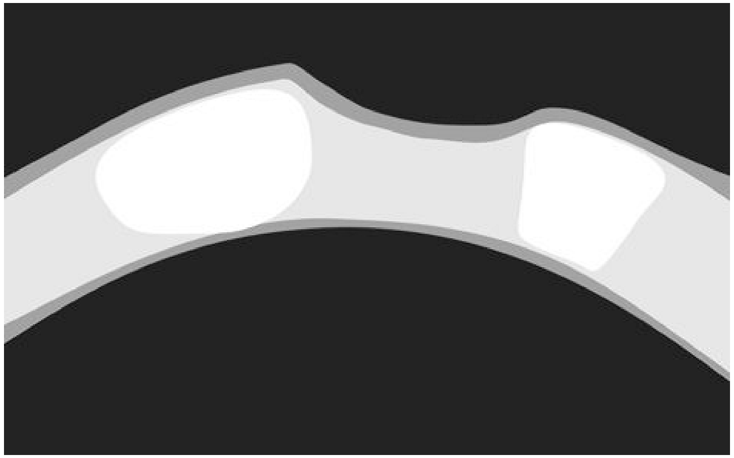
The bone-condensing technique was introduced to increase primary stability of dental implants in the posterior maxilla. This implant site preparation technique involves the use of implant-shaped instruments (bone condensers) by which the bone is compressed apically and laterally rather than removed. Bone condensing preserves as large a volume of existing maxillary bone as possible and increases its density so as to optimize the primary stability of implants in low-density bone [34]. Condensation significantly increases bone density in apical peri-implant area in relation to standard surgical technique [35].With osteotomes, Type D4 bone can be changed into Type D3 or Type D2 bone. Type D3 bone can generally be compacted to resemble Type D2. The following steps are involved when condensing bone with the osteotome technique.

Osteotome- Assisted Lateral Bone Expansion and Condensation

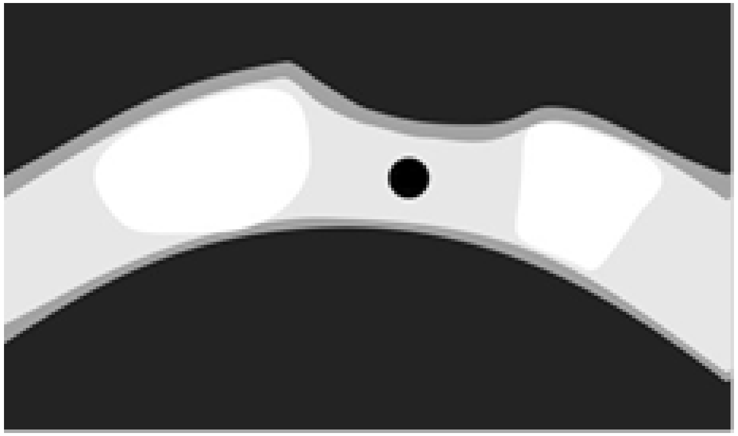
The word osteotome is derived from the Latin words 'osteo', meaning bone and 'tome', meaning to incise or cut. In the field of implant dentistry Dr. Hilt Tatum coined the word in the early

1970s to describe a special set of hand instruments developed to form or shape bone in preparation for the replacement of dental implants. This bone expansion technique addresses the natural resorptive pattern of the premaxilla. Resorption from the buccal aspect often results in

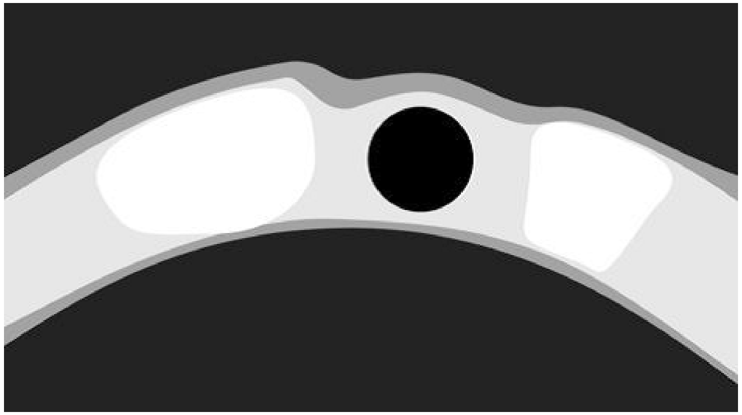
inadequate ridge width for ideal implant placement. The ridge is often wider at the crest, with a labial undercut at the midroot area (Figure 6).



6(a)



6(b)



6(c)

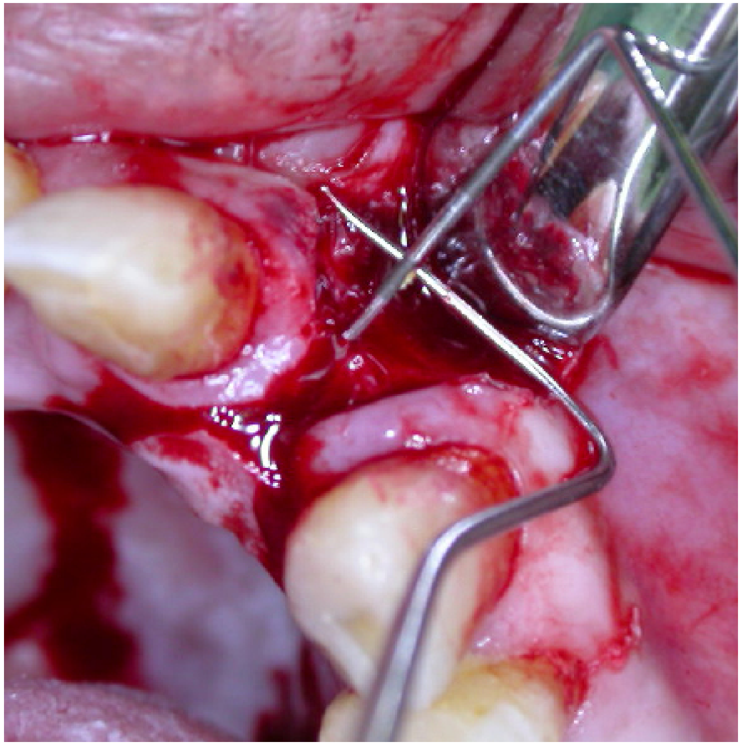
Figure 6: Graphic representation of coronal section showing horizontal bone loss then with 2 mm pilot drill then use of progressive tapered osteotome to condense and manipulate the crestal bone, increasing the horizontal dimension.

The bone is mostly trabecular in nature with a thin layer of cortical bone on the labial and crest of the ridge. The palatal wall is dense cortical bone. By using specially designed instruments, it is possible to treat premaxilla without soft tissue reflection through an incision that is 3 mm long. This technique, in combination with modern restorative materials and concepts, can produce restorations that rival the esthetic results of alternative treatments, bone grafting, or soft tissue manipulation [36].

Osteotome Technique with Immediate Implant Placements

At the time of surgery, the patient was prepared in a sterile environment. Preoperative antibiotics were prescribed to the patient prior to surgery. With the patient under local anesthesia, a full-thickness flap was elevated using a mid-crestal incision and 2 buccal and palatal incisions (Figure 7).

7(a)

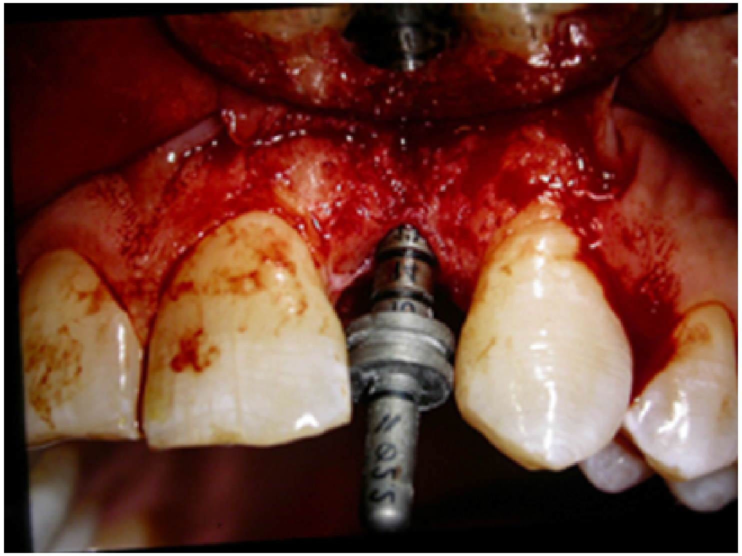


7(b)

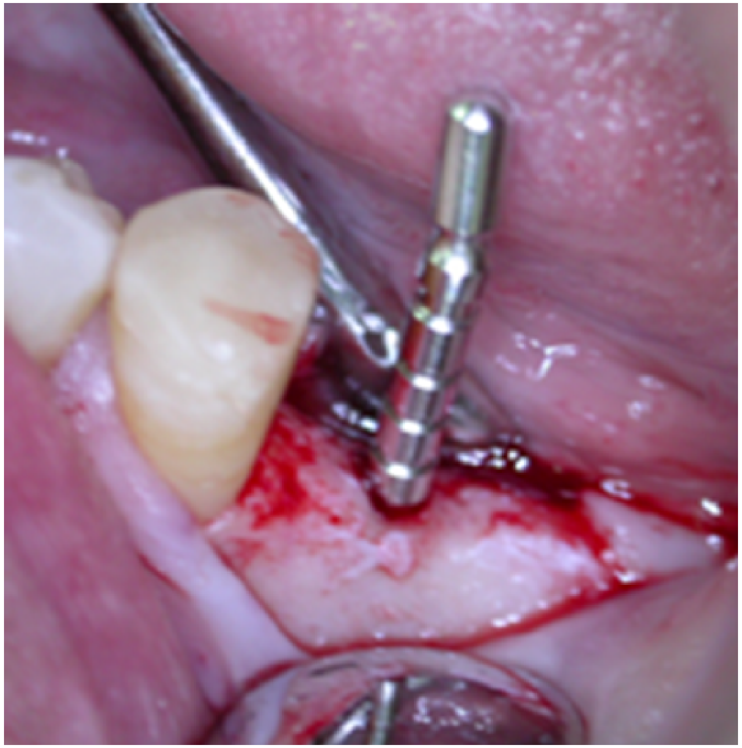
Figure 7: A full-thickness flap was elevated using a mid-crestal incision and 2 buccal and palatal releasing incisions.

This revealed further bone concavity on the buccal aspect (Figure 3). The bone was accessed and marked with a round bur. Prior to the use of the osteotome technique; the bone quality was determined clinically by drilling with a 2.2-mm-diameter pilot twist drill to a depth of 11-12

mm to allow for complete insertion of the full length of the 10-mm implant plus 1 mm for bone remodeling. A depth gauge was used as distance indicator to determine the length of the preparation (Figure 8).



8(a)

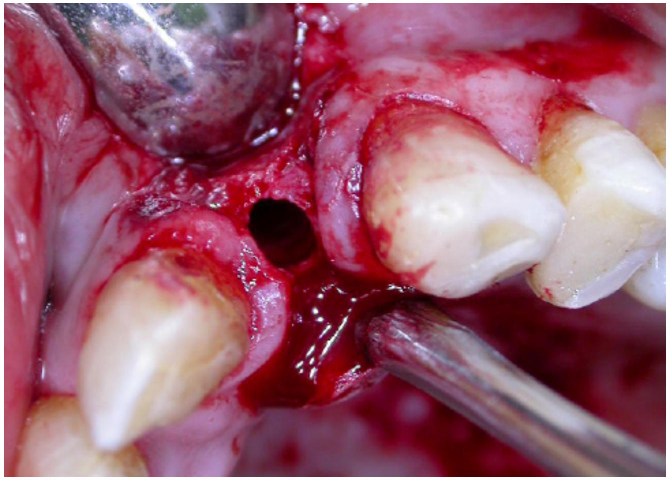


8(b)

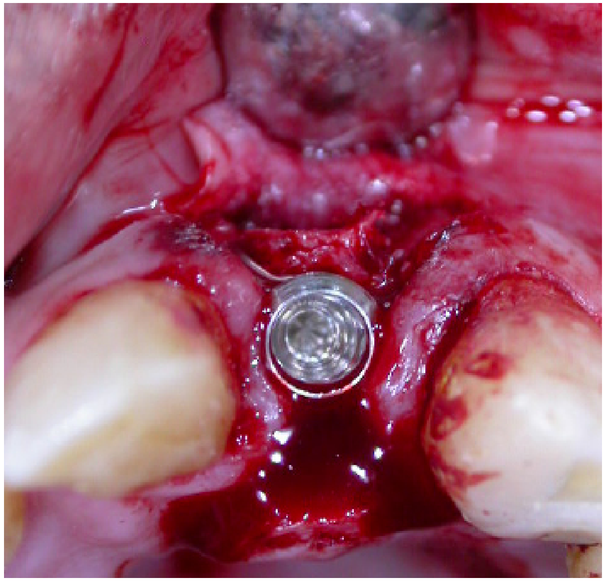
Figure 8: A depth gauge was used as distance indicator to determine the length of the preparation.

To improve the bone density and primary stability, bone condensation was attained through radial reinforcement using series of bone condensation devices with a tapered tip and an appropriate diameter 2.2 mm to 3.5 mm to widen the implant bed (ITI osteotome instruments for

bone condensation, Institute Straumann, Basel, Switzerland). Extreme care was taken to proceed with the osteotome technique as slowly as possible. Because there was a degree of resistance, the ridge was allowed to spread for 30 to 60 seconds with the osteotome left in place before the next-size-larger osteotome was used, and it is important to leave the osteotome in place for approximately 1 minute to allow for flexure of the bone while compressing the buccal and palatal bony plates simultaneously (fig. 4). This is important because the bone needs time to accommodate to the expansion. Tactile sensation is an essential part of this ridge expansion process, particularly during the insertion of the next larger sized osteotome. It should be stressed that rapid expansion and denser bone would result in a fracture of the buccal bone plate and should be prevented as much as possible (Figure 9) otherwise, Guided Bone Regeneration (GBR) will be appropriate for such cases with autogenous bone graft can be taking from the same implant socket (Figure 9 A through E).

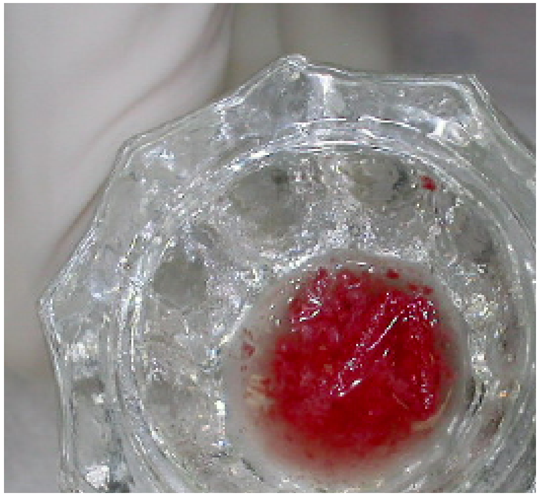


9(a)

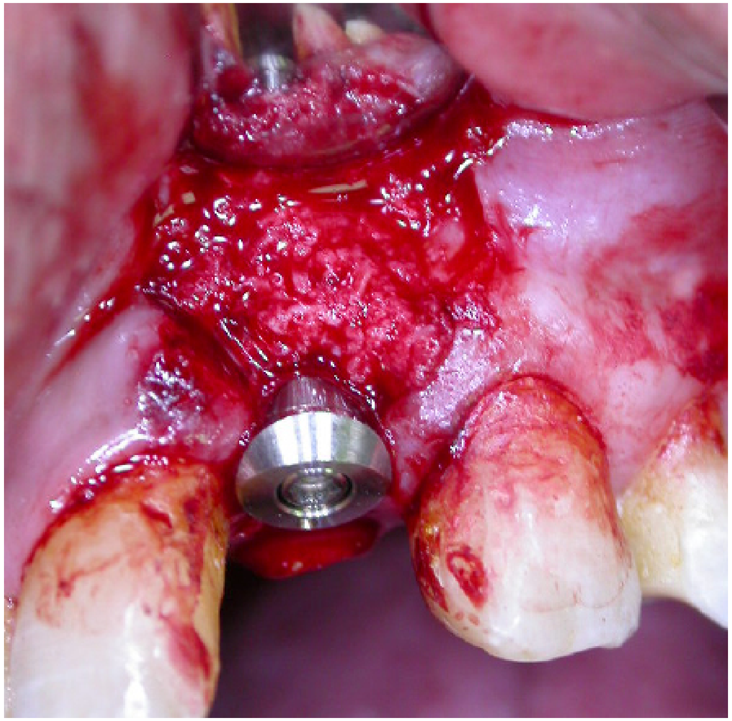


9(b)

9(c)



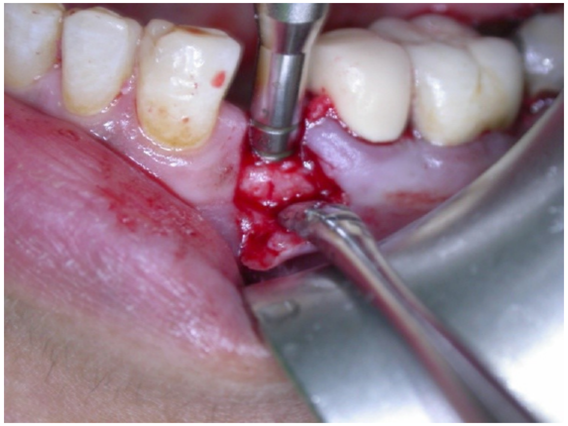
9(d)



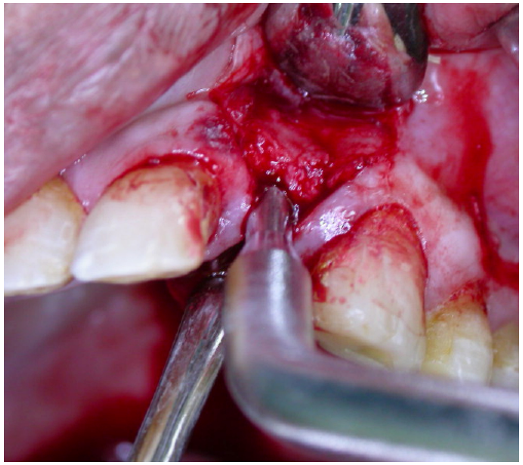
9(e)

Figure 9: A. The final diameter of the implant bed was established and the crestal bone thickness reached less than 6.35 mm bucco-lingually, B. Rapid expansion and denser bone would result in a fracture of the buccal bone plate, C. Autogenous bone graft can be taking from the same implant socket, D. Collected in surgical dapping dish, E. The autogenous bone graft was used to fill the gap after osteotome technique with immediate implan tplacement.

The osteotomes were inserted and removed along a straight path (Figure 10) [5].



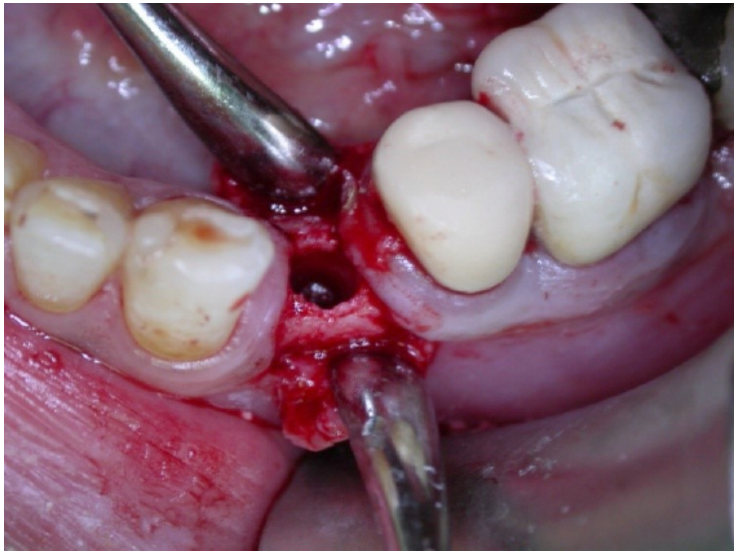
10(a)



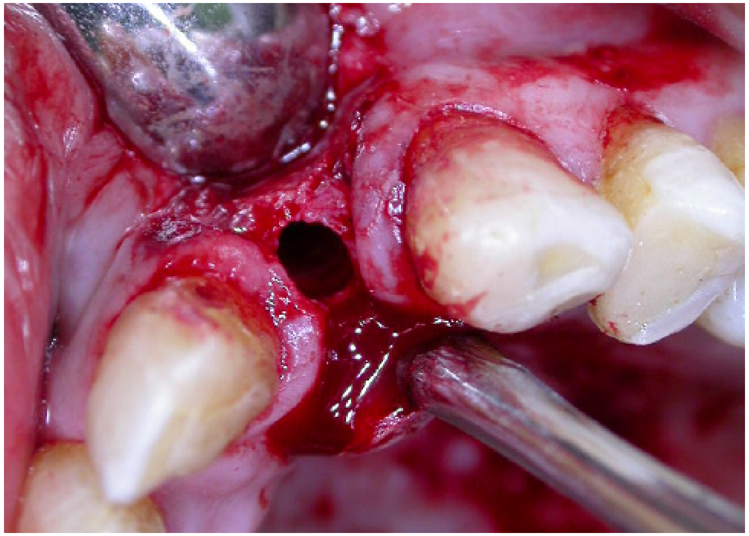
10(b)

Figure 10: The osteotomes were inserted and removed along a straight path and mesiodistal direction to reduce the stress on the buccal and lingual bone plate.

Because the bone quality was subjectively judged to be Type II or III and the concavity was on the buccal side, the decision was made to condense the bone laterally and expand it vertically to prevent the ovalization of the implant bed in the limited residual bone. After the final diameter of the implant bed was established and the crestal bone thickness reached 6.35 mm or more, based on the implant diameter and consider a minimum of 1 mm of bone around the implant (Figure 11).



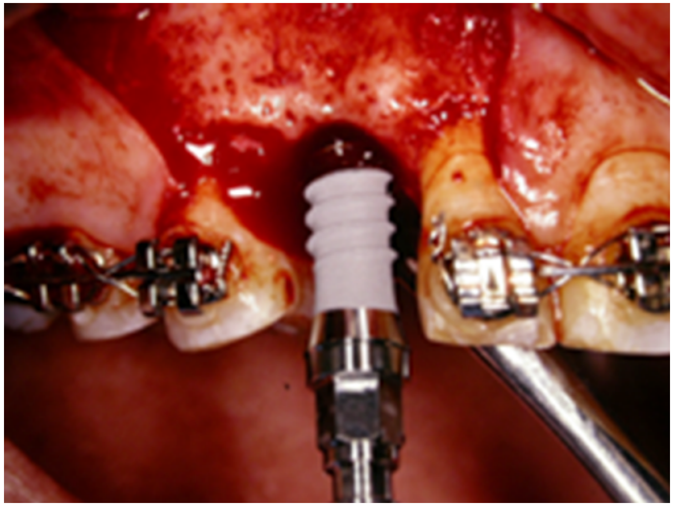
11(a)



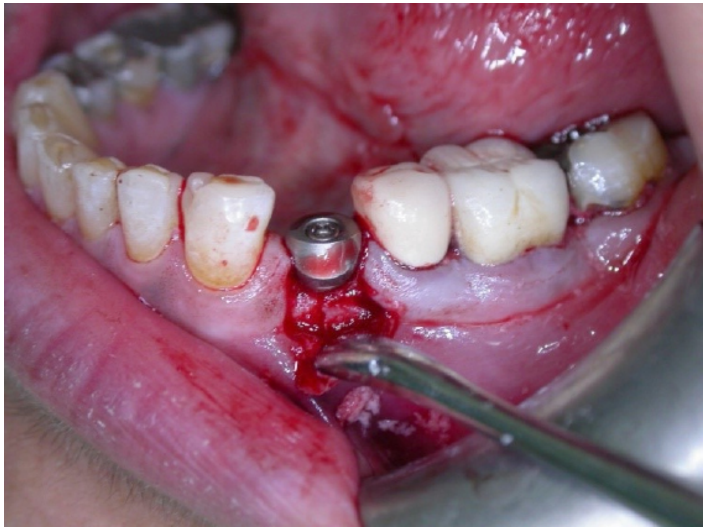
11(b)

Figure 11: After the final diameter of the implant bed was established and the crestal bone thickness reached 6.35 mm or more, based on the implant diameter and consider a minimum of 1 mm of bone around the implant.

Endosseous implant will be placed immediately after the bone expansion was completed (Figure 12).



12(a)



12(b)

Figure 12: Endosseous implant will be placed immediately after the bone expansion was completed.

Leaving the osteotomy slightly narrower than the diameter of the implant allowed the implant to self-tap and achieve good primary stability.

Gentle manual turning of the implant facilitated its insertion to the required implant height and achieved primary stability.

Figure 13 demonstrated the intraloral view after 6 weeks of healing with good soft-tissue healing and osteotome-assisted lateral bone expansion and condensation with immediate dental implant placement with good intact alveolar ridge.

13(a)

13(b)

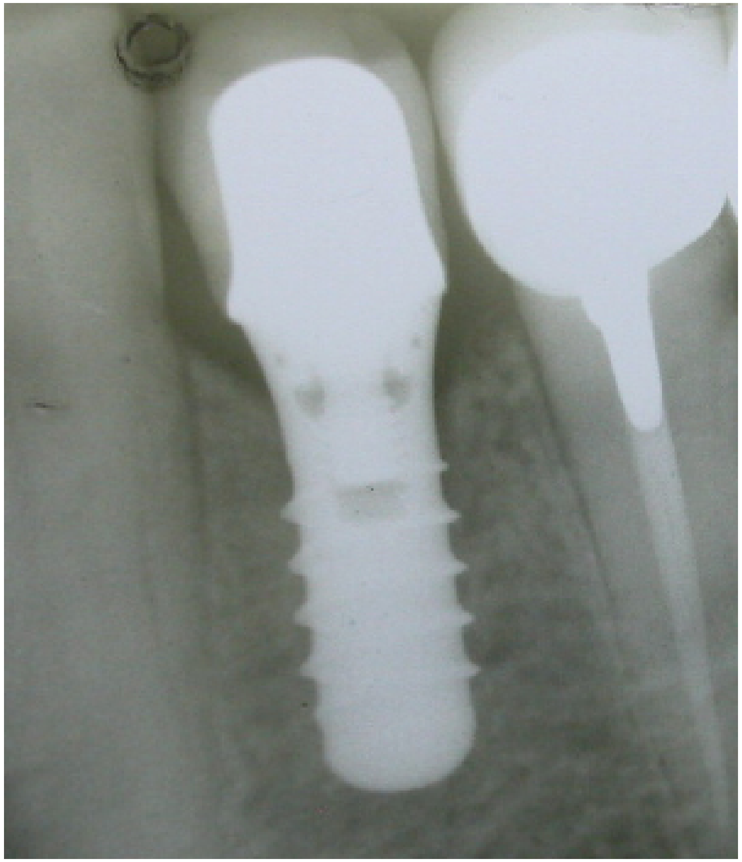
Figure 13: Intraloral view after 6 weeks of healing with good soft-tissue healing and intact alveolar ridge.

Figure 14 shows the amount of bone expansion achieved and good esthetic results obtained with the prosthesis was achieved in place (Figure 14). Periapical X-ray had been taken after implant placement, and one-year of implant's functional loading which showed the amount of bone resorption one-year of implant's functional loading (Figure 15) [36].

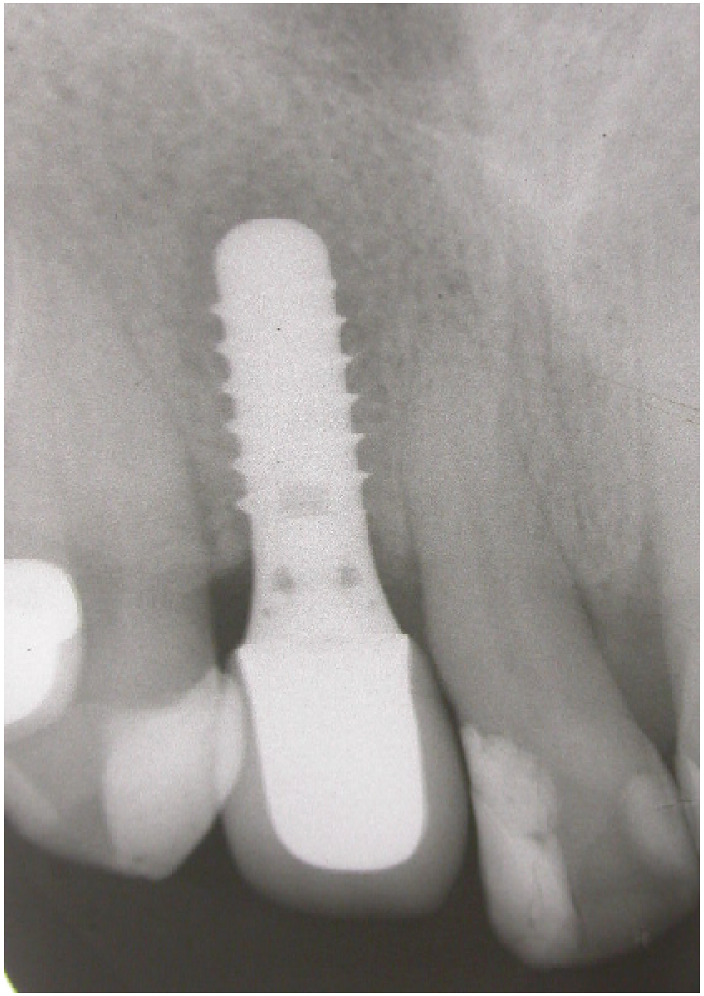
14(a)

14(b)

Figure 14: Final prosthesis in place.



15(a)



15(b)

Figure 15: Preiapical radiograph showing the implant and surrounding bone after the restoration and functional loading of the implant.

Benefits to Use Sandblasted, Acid-Etched, and Active (SLA active) Screw-Type ITI Implant (Straumann Schweiz (Basel, Switzerland)

According to Marinucci et al [37] and others [38-42] this surface treatment is biocompatible, allowing the attachment, proliferation and differentiation of osteoblasts, thus optimizing osseointegration and enhancing the clinical function of implants. In addition, the compression of bone to improve bone density has been successfully utilized in reconstructive surgery [43]. With modifications, this method has been introduced to dental implantology. The use of the osteotome technique has been investigated in clinical studies with emphasis given on the survival rate of the implants [44-49]. This is in accordance with Ernesto and Anitua [50], where they reported that previously complex sites having narrow buccolingual width that needed ridge augmentation prior to implant placement with the subsequent hazards of bone grafts and membranes, can be treated with one stage approach provided that adequate stability is achieved. Thus, continuous efforts have been made to develop "tissue compatible" implants, which are compatible with the surrounding host tissues to assure the development of a bone metal interface. In addition, different researches were introduced to improve bone density and the quality of the implant site to obtain higher osseointegration percentages [51].

In addition to thread engagement, body design and surface roughness help to provide a frictional interface with the receptor site, this inturn, will assist in mechanical retention by facilitating bone ingrowths during osseointegration [52]. Numerous investigators have reported that SLA rough surfaces of the ITI implants, obtain a stronger bone anchorage when compared with smooth titanium surface and can also positively influence cellular and tissue responses to implants [53-59]. A positive correlation exists between implant surface roughness and the degree of initial and long-term mechanical fixation [52, 60]. The macro and micro roughness, and the performance of the rough SLA surface is superior to smooth surfaces with respect to bone contact levels, removal torques and micro-texture (due to the acid etching) of the implant. It has been found to osseointegrate even under immediate, full occlusal loading conditions [61-63].

It is remarkable that implant surface is as much important as the surgical technique in clinical survival rate. Experimental data showed that new implant surfaces, such as the SLA (Sandblasted, Large grit and Acid etched); promote greater osseous contact at earlier time points [64-66]. Due to the amount of bone resorption (dent-alveolar defect) for this clinical case we can figure out the importance of an atraumatic tooth extraction and immediate or early implant placement into extracted socket [67].

Comparison of Osteotome Technique with Conventional Implant Placement with Burs

Different studies showed an animal histologic study compared the osteotome technique to conventional implant placement with burs in 52 New Zealand white rabbits using 104 implants placed in the distal femoral condyles [51]. The implants were studied after 2, 4, and 8 weeks of placement. The authors concluded that the osteotome technique increases new bone formation and leads to an enhanced osseointegration of dental implants in trabecular bone. In a multicenter study, this technique has shown success rates as high as 96% [68]. Another study evaluated sinus elevation along with the osteotome technique in a longitudinal radiographic study and concluded that the osteotome technique represents a substantially less-invasive alternative for predictable implant installation in maxilla [69]. Initial stability of the implant was attained by lateral condensation. The lateral condensation technique performed using a series of osteotomes promotes better initial stability . The quality of bone with a dense cortical plate increases the initial stability. In addition to thread engagement, the body design and surface roughness of the implants provided a frictional interface with the receptor site to assist in the mechanical retention by facilitating bone ingrowth during osseointegration [70]. Buchter et al compared the influence of the osteotome technique on the osseointegration and biomechanical behaviour of cylinder implants (SLA, ITI) with a conventional preparation of the implant site in an animal mode (six Gottinger minipigs). They conclude that the decreased implant stability by using the osteotome technique is based on microfractures in peri-implant bone. Therefore, Considerable care needs to be taken in their use due to the possibility of uncertain amount and direction of force being exerted towards the apex [71]. Lateral condensation technique by series of osteotomes helps in attaining better initial stability [52,72,73]. The quality of bone with a dense cortical plate may also aided in providing the initial stability. Strietzel et al. reported in their study that the use of the osteotome technique in good quality bone (types 1 and 2) produces more bone resorption than the standard technique [64]. This may be due to the higher forces for bone compression applied in the compact bone. If much force is used to insert implants, the trauma on the bone will cause more bone resorption and osseointegration will take more time [56].

Advantages of Osteotome Technique over the Traditional Graded Series of Drills

- Drilling removes bone. When adequate quantities of dense bone are available, this is not a problem. But when the alveolar bone is compromised in quality or quantity, the need is to preserve the re-

maining bone and improve its quality. This technique retains the total bone mass.

- It is an alternative to block grafting in select cases to increase the ridge width for implant placement.
- Allows immediate placement of implants in narrow ridges at the time of expansion.
- Osteotomes take advantage of the fact that bone is viscoelastic and can be compressed and manipulated. Compression creates a denser bony interface with increased bone to implant contact and therefore good initial stabilization of the dental implant.
- Heat is a major detriment to osseointegration, but the osteotome technique is an essentially heatless and therefore should not destroy the viable bone-forming cells.
- This technique also allows for greater tactile sensitivity.
- It is minimally invasive and cost effective.
- Faster prosthetic restoration is possible.

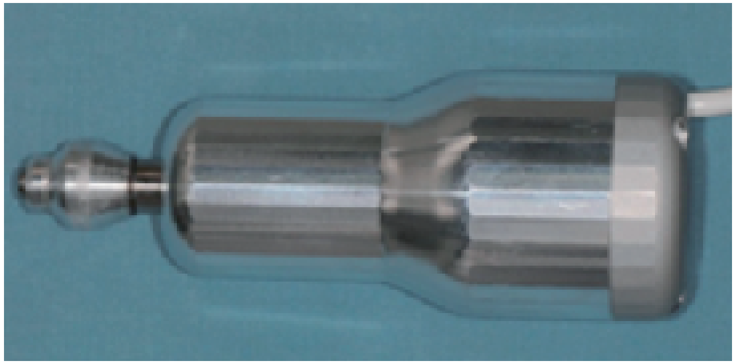
Comparison of Bone Expanders by Motorized Expander Drills and Osteotome Kit

The osteotomes are used almost exclusive for the compaction of type IV and V bone, as well as for the summer atraumatic sinus lift. The osteotome kit works sometimes through hammer taps also seems to be excessively traumatic for the patient, because in most cases we found thick cortical plates and type II bone with a cortical layer. Different studies showed the limitation of the osteotome technique compare to Microdent threaded expanders that it is mainly designed for the maxilla. Additionally the “palmheld” design requires considerable force to be used, which can be intimidating for most clinicians because there is the risk of too much force been applied with resultant fracture of the osteotomy site [74,75] (Figure 16).

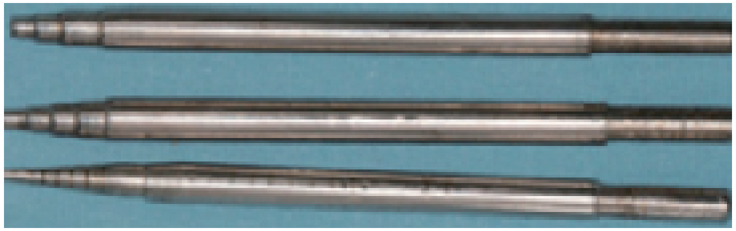
Figure 16: Microdent threaded expanders that it is mainly designed for the maxilla.

Compare the Use of Hand Mallet Versus Electrical Mallet in Osteotome-Assisted Surgery for Lateral Bone Expansion and Condensation in Edentulous Molar and Premolar Maxillary Regions

The use of magnetic mallet provided essential advantages both for operator and patient in comparison with hand mallet [76] (Figure 17). During surgical procedure, magnetic mallet delivered a more precise control of osteotome of the entry direction (or directionality) of the tip into the bone. This is an important concept because bone is generally formed of parts with different density and that the expander tends to be deflected when it moves from a bone part with a specific density to another bone part with a different density. The handling of the device is very simple because the mechanical oscillations transmitted to the osteotome are transmitted without difficulties to the bone. Furthermore, this procedure improved the patient comfort avoiding benign paroxysmal positional vertigo (BPPV).



17(a)



17(b)

Figure 17: Magnetic mallet and osteotomes.

Vertical Splitting of the Bone Mandible which is Alternative for Inferior Alveolar Nerve Latinization by Means of Ostoetomies using Pezioelectrical Surgery Following by Bone Expansion

Redrigues and eldibany evaluated a modified technique to inferior alveolar nerve laterlization (IANL) that allows the placement of longer implants in the posterior mandibular region. Vertical splitting of mandibular body was performed using piezoelectric surgery followed by bone expansion and insertion of special conical implants of 10 and/or 12 mm in length [77]. This is a simple procedure that has no limitation in clinical situation with minimal bone height. It allows for greater implant stability, and the risk of neurological disturbance is minimal.

Conclusion

Osteotome-assisted lateral bone expansion and condensation with immediate dental implant placement is a gentle technique; offers advantages for patients include less surgical trauma, a shorter treatment time, and reducing the need for costly procedures. This technique offers a viable alternative to bone grafting in select cases for lateral bone expansion where teeth have been missing for a considerable period of time. Further investigations including a large number of patients and considering long-term evaluation of peri-implant alveolar loss bone are necessary to enhance the power of the conclusions concerning use and predictability for this technique.

References

1. McAllister BS, Haghighat K. Bone augmentation techniques. J Periodontol. 2007; 78: 377-396.
2. Engelke W, Diederichs C, Jacobs H, Deckwer I. Alveolar reconstruction with splitting osteotomy and microfixation of implants. International Journal of Oral Maxillofacial Implants. 1997; 12: 310-318.
3. Nishioka RS, Souza FA. Bone Spreader Technique: A Preliminary 3-Year Study J of Oral Implanol. 2009; 35: 289-294.
4. Khairnar MS, Khairnar D, Bakshi K. Modified ridge splitting and bone expansion osteotomy for placement of dental implant in esthetic zone. Conemp Clin Dent. 2014; 5: 110-114.
5. Summers RB. The osteotome technique. Part 2 The ridge expansion osteotomy (REO) procedure. Compendium of Continuing Education in Dentistry. 1994; 15: 422-434.
6. Stavropoulos A, Nyengaard JR, Lang NP, Karring T. Immediate loading of single SLA implants: Drilling vs. osteotomes for the preparation of the implant site. Clin Oral Implants Research. 2008; 19: 55-65.

7. Hahn J. Clinical uses of osteotomes. J Oral Implantol 1999; 25: 23-29.

8. Atwood DA. Postextraction changes in the adult mandible as illustrated by microradiographs of midsagittal sections and serial cephalometric roentgenograms, J Prothet Dent. 1963; 13: 810-824.

9. Atwood DA, Coy WA. Clinical, cephalometric and desitometric study reduction of residual ridges, J Prothet Dent. 1971; 26: 280–295.

10. Misch CE. Contemporary implant dentistry. 3rd ed. St. Louis, MO; Mosby Elsevier Canada; 2008.

11. Cawood JJ, Howell RA. A classification of the edentulous jaws classes I to VI, Int J Oral Maxillo Surg. 1988; 17: 232–279.

12. Weiss CM, Judy KWM. Sever mandibular atrophy: biological considerations of routine treatment with complete subperiosteal implant, J Oral Implant. 1974; 4: 431–469.

13. Kent JN. Correction of alveolar ridge deficiencies with non-resorbable hydroxyapatite, J AM Dent Assoc. 1982; 105: 99–100.

14. Lekholm U, Zarb GA. Patient selection and preparation, in Brånemark P-I, Zarb GA, Albrektsson T (eds): Tissue-Integrated Prostheses: Osseointegration in Clinical Dentistry. Chicago, Quintessence Publ Co. 1985; 199–209.

15. Misch CE. Treatment planning and implant dentistry (abstract), Misch Implant Institute Manual, Dearborn, Misch. 1985

16. Misch CE. Divisions of available bone in implant dentistry, Int J Oral Implant. 1990; 7: 9–17.

17. Studer S, Naef R, Scharer P. Adjustment of localized alveolar ridge defects by soft tissue transplantation to improve mucogingival esthetics: a proposal for clinical classification and an evaluation of procedures. Quintessence Int. 1997; 28: 785–805.

18. Seibert JS. Reconstruction of deformed, partially edentulous ridges, using full thickness onlay grafts. Part II. Prosthetic/periodontal interrelationships. Compend Contin Educ Dent. 1983; 4: 549–562.

19. Allen EP, Gainza CS, Farthing GG, Newbold DA. Improved technique for localized ridge augmentation: A report of 21 cases. J Periodontol. 1985; 56: 195–199.

20. Studer S, Naef R, Scharer P. Adjustment of localized alveolar ridge defects by soft tissue trans-

plantation to improve mucogingival esthetics: a proposal for clinical classification and an evaluation of procedures. Quintessence Int. 1997; 28: 785–805.

21. Seibert JS. Reconstruction of deformed, partially edentulous ridges, using full thickness onlay grafts. Part II. Prosthetic/periodontal interrelationships. Compend Contin Educ Dent 1983; 4: 549–562.
22. Allen EP, Gainza CS, Farthing GG, Newbold DA. Improved technique for localized ridge augmentation: A report of 21 cases. J Periodontol. 1985; 56: 195–199.
23. Misch CE. Bone character: second vital implant criterion. Dent Today. 1988; 7: 39.
24. Misch CE. Density of bone: effect on treatment planning, surgical approach, and healing. In: Misch CE, editor. Contemporary Implant Dentistry. St. Louis: Mosby. 1993; 469– 485.
25. Misch CE, Kircos LT. Diagnostic imaging and techniques. In: Misch CE, editor. Contemporary Implant Dentistry. 2nd edn. St. Louis: Mosby. 1999; 73–87.
26. Kravitz ND, Kusnoto B, Tsay TP, Hohit WF. The use of temporary anchorage devices for molar intrusion. J Am Dent Assoc. 2007; 138: 56–64.

27. Engelke WG, Diederichs CG, Jacobs HG, Deckwer I–Alveolar reconstruction with splitting osteotomy and microfixation of implants; Int J Oral Maxillofac Implants. 1997; 12: 310–318.
28. Federico Brugnami and Cristiano Caleffi – Prosthetically driven Implant Placement. How to achieve the appropriate implant site development. Keio J Med 2005; 54: 172–178.Simion
29. M. Baldoni M, Zaffe D. Jawbone enlargement using immediate implant placement associated with a split-crest technique and guided tissue regeneration. Int. J Periodontics Restorative Dent. 1992; 12: 462–473.
30. Dennis Flanagan. Cortical Bone Spreader Osteotome and Method for Dental Implant Placement; Journal of Oral Implantology. 2002; 28: 295–296.
31. De Wijs FL. Spliting and widening of a narrow jaw ridge in the edentulous maxilla; Ned T i - jdschr Tandheelkd. 1997; 104: 262–263.
32. Tomoo Oda, Hidebaru Suzuki, Masataka Yokata, Minoru Ueda. Horizontal Alveolar Distraction of the Narrow Maxillary Ridge for Implant Placement; J Oral Maxillofac Surg. 2004; 62: 1530–1534.
33. Borgner, Kirkos, Gougaloff, Cullen, Delk. Computerized tomography scan interpretation of a bone expansion technique. J Oral Implantol. 1999; 25:102–108.

34. Summers RB. A new concept in maxillary implant surgery: the osteotome technique. Compendium. 1994; 15: 152–162.

35. Blanco J, Suarez J, Novio S, Villaverde G, Ramos I, Segade LAG. Histomorphometric assessment in cadavers of the periimplant bone density in maxillary tuberosity following implant placement using osteotome and conventional techniques. Clin Oral Implants Res. 2008; 19: 505–510.

36. Al-Almaie S. Immediate Dental Implant Placements Using Osteotome Technique: A Case R e - port and Literature Review. Open Dent J. 2016; 10: 367–374.

37. Lorella Marinucci, Stefania Balloni, Ennio Becchetti, Salvatore Belcastro, Mario Guerra, et al. Effect of titanium surface roughness on human osteoblast proliferation and gene expression in vitro. Int J Oral Maxillofac Implants. 2006; 21: 719–725.

38. Butz E, Aita H, Wang CJ, Ogawa T. Harder and stiffer bone osseointegrated to roughened titanium. J Dent Res. 2006; 85: 560–565.

39. Cooper L. A role for surface topography in creating and maintaining bone at titanium endosseous implants. J Prosthet Dent. 2000; 84: 522–543.

40. Borsari V, Giavaresi G, Fini M. Comparative in vitro study on an ultra-high roughness and dense titanium coating. Biomater. 2005; 26: 4948–4955.

Dental Implants

41. Alberktsson T, Wennerberg A. Oral implant surfaces: Part 2 review focusing on clinical knowledge of different surfaces. Int J Prosthodont. 2004; 17: 544–564.

42. Giavaresi G, Fini M, Rimondini L, Giordino R. Histomorphometric and microhardness assessment of sheep cortical bone surrounding titanium implants with different surface treatments. J Biomedical Mater Res 2003; 54: 112–120.

43. Büchter A, Kleinheinz J, Wiesmann HP, Kersken J, Nienkemper M, et al. Biological and biomechanical evaluation of bone remodelling and implant stability after using an osteotome technique. Clin Oral Implants Research. 2005; 16: 1–8.

44. Glauser G, Naef, R, Schärer P. The osteotome technique a different method of implant placement in the posterior maxilla. Implantol. 1998; 2: 103–120.

45. Komarnyckyj OG, London RM. Osteotome single-stage dental implant placement with and without sinus elevation: a clinical report. Int J Oral Maxillofac Implants. 1998; 13: 799–804.

46. Zitzmann NU, Schärer P. Sinus elevation procedures in the resorbed posterior maxilla. Comparison of the crestal and lateral approaches. Oral Surg Oral Med Oral Pathol Oral Radiol Endo. 1998; 85: 8–17.

Dental Implants

47. Fugazzotto PA. Sinus floor augmentation at the time of maxillary molar extraction: technique and report of preliminary results. Int J Oral Maxillofac Implants. 1999: 14: 536–542.

48. Rosen PS, Summers R, Mellado JR, Salkin LM, Shanaman RH, *et al.* The bone-added osteotome sinus floor elevation technique: multicenter retrospective report of consecutively treated patients. Int J Oral Maxillofac Implants. 1999; 14: 853–858.

49. Silverstein LH, Kurtzman GM, Moskowitz E, Kurtzman D, Hahn J. Aesthetic enhancement of anterior dental implants with the use of tapered osteotomes and of soft tissue manipulation. J Oral Implantol. 1999; 25: 18–22.

50. Lee Ernesto A, Anitua E. Atraumatic ridge expansion and implant site preparationwith bone expanders. Pract Proced Aesthet Dent. 2006; 18: 17–22.

51. Nkenke E, Kloss F, Wiltfang J, Schultze-Mosgau S, Radespiel-Tröger M, et al. Histomorphometric and fluorescence microscopic analysis of bone remodeling after installation of implants using an osteotome technique. Clin Oral Implants Res. 2002; 13: 595–602.

52. Skalak R, Zhao Y. Interaction of force-fitting and surface roughness of implants. Clin Implant Dent Relat Res 2000; 2: 219–234.

53. Wilke HJ, Claes L, Steinemann S. The influence of various titanium surfaces on the interface shear strength between implants and bone. Advances of Biomaterials 1990; 9: 309–311.

54. Buser D, Schenk RK, Steinemann S, Fiorellini JP, Fox CH, et al. Influence of surface characteristics on bone integration of titanium implants. Histomorphometric study in miniature pigs. Journal of Biomedical Materials Research. 1991; 25: 889–902.

55. Buser D, Nydegger T, Oxland T, Cochran D L, Schenk R K, et al. Interface shear strength of titanium implants with a sandblasted and acid-etched surface: A biomechanical study in the maxilla of miniature Pigs. Journal of Biomedical Materials Research 1999; 45: 75–83.

56. Cochran DL. A comparison of endosseous dental implant surfaces. Journal of Periodontology 1999; 70: 1523–1539.

57. Buser D, Mericske-Stern R, Bernard JP. Long-term evaluation of non-submerged ITI Implants. Clinical Oral Implants Research 1997; 8: 161–172.

Dental Implants

58. Ferrigno N, Laureti M, Fanali S, Grippaudo G. A Long-term follow-up study of non-submerged ITI implants in the treatment of totally edentulous jaws. Clinical Oral Implants Research 2002; 13: 260–273.

59. Nedir R, Bischof M, Briaux JM. A 7-year life table analysis from a prospective study on ITI implants with special emphasis on the use of short implants. Clinical Oral Implants Research 2004; 15: 150–157.

60. Rosenlicht JL. Swiss Plus implant system. Part 1: Surgical aspects and inter-system comparisons. Implant Dent 2002; 11: 144–153.

61. Cochran DL, Schenk RK, Lussi A, Higginbottom FL, Buser D. Bone response to unloaded and loaded titanium implants with a sand-blasted and acid-etched surface: A histometric study in the canine mandible. J Biomed Mater Res. 1998; 40: 1–11.

62. Li D, Ferguson SJ, Beutler T, Cochran DL, Sittig C, et al. Biomechanical comparison of the sandblasted and acid-etched and the machined and acid-etched titanium surface for dental implants. J Biomed Mater Res. 2002; 60: 325–332.

63. Bornstein MM, Lussi A, Schmid B, Belser UC, Buser D. Early loading of non-submerged titanium implants with a sandblasted and acid-etched (SLA) surface: 3-year results of a prospective study in partially edentulous patients. Int J Oral Maxillofac Implants. 2003; 18: 659–666.

64. Cochran DL, Schenk RK, Lussi A, Higginbottom FL, Buser D, et al. Bone response to unloaded and loaded titanium implants with a sandblasted and acid-etched surface: a histometric study in the canine mandible. Journal of Biomedical Material Research. 1998; 40: 1–11.

65. Szmukler-Moncler S, Perrin D, Ahossi V, Magnin G, Bernard JP, et al. Biological properties of acid etched titanium implants: effect of sandblasting on bone anchorage. Journal of Biomedical Material Research Part B: Applied Biomaterials. 2004; 68: 149–159.

66. Shalabi MM, Wolke JG, de Ruijter AJ, Jansen JA. A mechanical evaluation of implants placed with different surgical techniques into the trabecular bone of goats. Journal of Oral Implantology. 2007; 33: 51–58.

67. Kubilius M, Kubilius R, Gleiznys A. The preservation of alveolar bone ridge during tooth extraction. Stomatologija, Baltic Dental and Maxillofacial Journal. 2012; 14: 3–11.

68. Rosen PS, Summers R, Mellado JR, Marks MH, Fugazzotto PA, et al. The bone added osteotome

Dental Implants

sinus floor elevation technique: multicenter retrospective report of consecutive treated patients. Int J Oral Maxillofac Implants. 1999; 14: 853–858.

69. Bragger U, Gerber C, Joss A. Patterns of tissue remodeling after placement of ITI dental implants using an osteotome technique: a longitudinal radiographic case cohort study. Clin Oral Implants Res. 2004; 15: 158–166.

70. Büchter A, Kleinheinz J, Wiesmann HP, Kersken J, Nienkemper M, et al. Biological and biomechanical evaluation of bone remodelling and implant stability after using an osteotome technique. Clin Oral Implants Research. 2005; 16: 1–8.

71. Al-Almaie S. Staged Osteotome Sinus Floor Elevation for Progressive Site Development and Immediate Implant Placement in Severely Resorbed Alveolar Bone: A Case Report. Case Report in Dentistry. 2013; Article ID 310931: 1–6.

72. Summers RB. The Osteotome Technique: Part 3 – Less invasive methods of elevating the sinus floor. Compendium of Continuing Education in Dentistry. 1994; 15: 698–704.

73. Davarpanah M, Martinez H, Tecucianu JF, Hage G, Lazzara R, et al. The modified osteotome technique. Int J Periodontics Rest Dent. 2001; 21: 599–607.

74. Siddiqui A, Sosovicka A. Lateral bone condensing and expansion for placement of endosseous dental implants: A new technique. Journal of Oral Implantology. 2006; 32: 87–94.

75. Anitua Aldecoa E. BTI: New process for drilling, placing implants and obtaining autogenous bone. Dental Dialogue. Enero. 2004; 19: 4–15.

76. Roberto Crespi, Paolo Capparè, Enrico Gherlone. Electrical Mallet Provides Essential Advantages in Maxillary Bone Condensing. A Prospective Clinical Study. Clinical Implant Dentistry and Related Research. 2013 15: 874–882.

77. Redrigues JG, Eldibany RM. Vertical splitting of manibular body as an alterative to inferior alveolar nerve latrelization. Int. J. Oral Maxillofac. Surg. 2013; 42: 1060–1066.