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Review article

Osseodensification Technique – A Novel Bone Preservation Method to Enhance Implant Stability

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Abstract

Nowadays, dental implants have become a widespread treatment modality for replacing missing teeth. Success of implant therapy depends on primary implant stability, which influences osseointegration. Traditional drilling method excavates bone to create an osteotomy to receive implant fixture. A new promising technique, osseodensification, has recently been introduced that preserves the bone bulk by creating a layer of compacted bone along the surface of the osteotomy. This technique enhances the bone density around dental implants and increases primary stability. The purpose of this review article is to discuss the osseodensification procedure and its advantages over traditional drilling method in detail.

Keywords: Dental Implants; Primary Implant Stability; Osseointegration; Bone Density; Conventional Drilling; Osseodensification

Introduction

Nowadays, the replacement of lost natural tooth by means of dental implants has become a routine procedure in dental practice. Osseointegration, "a direct structural and functional connection between ordered, living bone and the surface of a load-carrying implant" [1], is a predominant parameter determining the success of an implant. However, a secure primary implant stability is essential for successful osseointegration and long-term successful clinical outcome of implant therapy [2,3]. Primary stability comes from the mechanical engagement between implant surface and bone walls of the osteotomic site at the time of surgical placement of the implant [4]. The achievement of primary implant stability depends on various patient-related [5,6], surgical procedure-related [7,8] and implant-related factors [9,10].

Bone density is considered as a key factor to take into account while predicting implant stability [11-13]. The quality and quantity of the histological structure of bone at the implant interface is strongly correlated with the density of bone available at the implant site [14] and bone strength is directly related to its bulk of mineral density and collagen integrity [15]. Therefore, it is important to preserve bone bulk during the preparation of an osteotomy in order to achieve implant stability and long-term clinical success.

Traditional drilling method for osteotomy preparation involves cutting and extraction of bone tissue to create a cylindrical hole that will receive an implant fixture [16] Over the past decades, several surgical techniques have been developed to improve conditions of local bone at implant recipient sites by preserving the existing bone volume and increasing its density, especially in situations where bone density is low. Sennerby [17] suggested that omission of the stage of bone tapping in low density bone might improve primary implant stability. Undersized implant site preparation is also recommended [18-20]. Degidi., *et al.* [20] reported a 10% undersized osteotomic implant site preparation in respect to the implant diameter to reduce bone cutting and enhance primary implant stability in the presence of poor-quality bone. In stepped osteotomy technique [21-23] the under preparation is performed only in the apical area of the implant site, whereas the crestal portion is treated with a standard protocol. Bone condensation technique with osteotomes [24,25] is another surgical technique aimed to compact the bone with the mechanical action of cylindrical steel instruments along the osteotomic walls to improve localized bone density. This technique consists of preparation of a small-sized pilot hole followed by compression of the bone tissue laterally and apically with a spreader or implant-shaped instrument. But this procedure seems to create trabecular fractures with debris, leading to an obstruction of the osseointegration process.

Recently, a new bone preserving, non-extraction site osteotomy preparation technique has been introduced for the preparation of implant bed based on an osseodensification drilling concept [26,27]. This review focuses on osseodensification technique and its advantages over traditional drilling osteotomy preparation technique.

The osseodensification Concept

Osseodensification is a novel, biomechanical, non-excavation osteotomy preparation technique developed by Salah Huwais in 2013. For this purpose, Huwais invented specially designed densifying burs called Densah burs (by Versah LLC- The osseodensification company). Unlike traditional drills, this drill design creates an environment which increases the primary stability by means of non-subtractive drilling [28]. Densifying burs combine the advantages of osteotomes with the speed and tactile control of the drills during osteotomy.

Osseodensification technique generates a layer of condensed autograft surrounding the implant along the surface of the osteotomy making it valuable in clinical settings where there is an anatomic paucity of bone. The logic behind osseodensification concept is that compacted, autologous bone immediately in contact with an endosteal device will not only have higher degrees of primary stability due to physical interlocking between the bone and the device, but also facilitate osseointegration due to osteoblasts nucleating on instrumented bone in close proximity to the implant [29].

Characteristics of densifying burs (Figure 1)

- A conically tapered body with a maximum diameter adjacent the shank and minimum diameter adjacent the apical end. This taper design controls the expansion process, as the bur enters deeper into the osteotomy.
- The apical end includes atleast one lip to grind bone when rotated in the counterclockwise/non-cutting/burnishing direction and cut bone when rotated in the clockwise/cutting/drilling direction.
- Helical flutes and interposed lands are disposed about the body. Each flute has a burnishing face and an opposing cutting face. The burnishing face burnishes bone when rotated in the burnishing direction and the cutting face cuts bone when turned in the cutting direction.
- At least one of the lip and the lands are configured to generate an opposing axial reaction force when continuously rotated in a burnishing direction and concurrently forcibly advanced into an osteotomy. This results in a push-back phenomenon, which provides the user enhanced control over the expansion procedure.

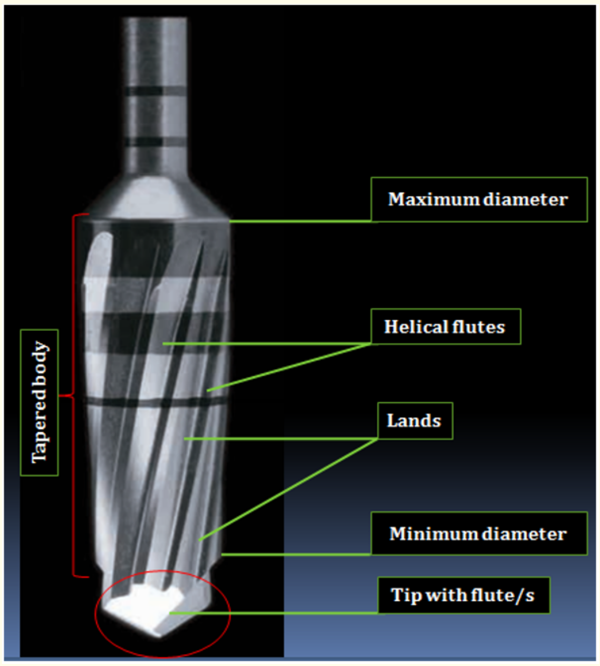

Figure 1: Characteristics of a densifying bur.

Osseodensification procedure

Densifying burs can be used with a standard surgical engine, rotating at 800-1200 rpm in the counterclockwise, non-cutting/burnishing direction (Densifying mode) to densify bone or in the clockwise cutting direction (Cutting mode) as a drill to cleanly cut the bone if needed (Figure.2). A downward surgical pressure coupled with profuse saline irrigation at the point of contact creates a compression wave inside the osteotomy that works with the fluting to create a densified layer along the walls and base of the osteotomy, through compaction and autografting the surrounding bone while plastically expanding the bony ridge at the same time. The irrigation fluid along with the fluid content of the bone helps this process by creating a lubrication film between the two surfaces to reduce friction and more evenly distribute the compressive forces. Bouncing motion of the bur (in and out of the osteotomy) is recommended, which will create a rate-dependent stress to produce a rate-dependent strain. This allows the saline irrigation to gently pressurize the bone walls and facilitates increased bone plasticity and bone expansion [4,28,31].

Huwais., *et al.* [31] reported that the diameter of the osseodensified osteotomy site was reduced by 91% of the bur diameter, when the osteotomy remained empty during imaging. This might be due to the spring-back effect of the compacted bone, caused by the residual strains of viscoelastic deformation created during the osteotomy preparation [32]. This spring–back effect creates compressive forces against the implant, thereby enhancing the bone-to-implant contact and primary stability, which have been shown to promote osteogenic activity through a mechanobiologic healing process [33].

Osseodensification technique versus traditional drilling method for osteotomy preparation (Table 1).

Osseodensification technique is a bone preservation method, whereas traditional drilling method involves cutting and

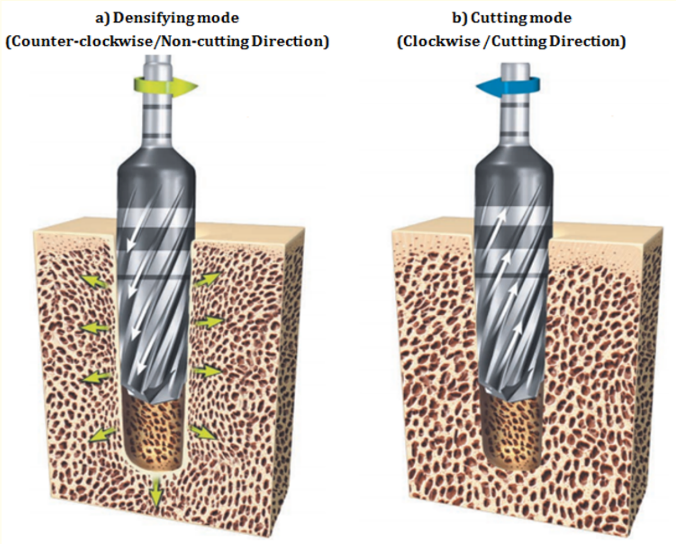

Figure 2: Dual use capability of densifying bur- a) Densifying mode- creates osseodensification; b) Cutting mode-precisely cuts bone.
(Image source: Densah® Bur and C-Guide™ Instructions for Use by Versah - the osseodensification company).

Technique	Osseodensification technique	Traditional drilling technique
Bone excavation	Non-excavation, bone preservation method, allows compaction - auto-grafting of bone with minimal trauma.	Involves cutting and excavation of bone tissue.
Bur design	Taper design with more than four lands and flutes and a tip with flute/s to guide through the osteotomy and eliminates potential chatter.	Regular twist drills have only two to four lands to guide them through the osteotomy
Osteotomy	Creates precise circumferential osteotomy Diameter of osteotomy is 0.5mm smaller than traditional drilling osteotomy.	May not always produce a precise circumferential osteotomy. May become elongated and elliptical due to chatter of the drills.
Heat generation	Heat generation is reduced with copious amount of saline external irrigation along with a bouncing-pumping motion of bur.	Heat generation during rotary cutting is a crucial factor influencing the development of osseointegration.
Implant placement Insertion torque Removal torque % Bone volume % Bone-implant contact Implant stability In narrow ridges	Higher (Compared to traditional drilling techniques) Facilitates expansion of narrow ridges in width. Allows larger diameter implant placement without creating bone dehiscence or fenestration.	Less (compared to osseodensification technique) Larger diameter implant placement may result in bone dehiscence or fenestration.

Table 1: Osseodensification technique Vs Traditional drilling technique.

excavation of bone tissue. It has been demonstrated that densifying drills increase the percentage bone volume and percentage bone-to-implant contact area for implants placed in low-density bone compared to traditional osteotomies, which may enhance osseointegration [4]. Drilled osteotomies may sometimes become elongated and elliptical due to chatter of the drills [34]. Lack of precise osteotomy may lead to reduced insertion torque, leading to poor implant stability. Heat generation during rotary cutting is one of the crucial factors influencing the development of osseointegration [35]. During drilling, temperature rises due to the plastic deformation and shear failure of bone and friction at the machining face, which may affect the viability as well as the structure and mechanical properties. These circumstances, may reduce the implant insertion torque, leading to poor primary stability and potential lack of integration to bone [27]. External irrigation with copious amount of saline along with a bouncing motion of bur used in osseodensification technique seems beneficial in reducing the heat generated during the osteotomy preparation [31].

The diameter of an osteotomy prepared by osseodensification is found to be smaller than conventional osteotomies prepared with the same burs [31]. The percentage of bone at the implant surface is reported to be increased by approximately three times for implants placed with osseodensification compared with standard drilling by creating a crust of increased bone mineral density around the osteotomy site [31].

Trisi., *et al.* [36] reported a significant increase in insertion torque and concomitant reduction in micromotion by bone compaction techniques with that of standard drilling. Lahens B., *et al.* [29] and Huwais., *et al.* [31] observed that osseous densification increased the insertion torque compared to standard drilling. High insertion torque can significantly increase the initial bone-to-implant contact percentage [37] and is found to be directly related to implant primary stability and host bone density [36]. High insertion torque is also important for achieving a good clinical outcome with early or immediate loading [38].

Higher removal torque values are noted with implants placed by osseous densification compared to drilling [4,31,39]. This may be due to the reverse compression applied to the implant by the compressed bone in osteotomy prepared by osseodensification.

Advantages of osseodensification technique

Osseodensification is a unique, highly controllable, fast and efficient bone preservation osteotomy preparation technique which results in increased primary stability, bone mineral density and percentage of bone at the implant surface leading to faster wound healing and enhanced osseointegration [27,28,31]. Healing process may be accelerated due to bone matrix, cells and biochemicals maintained and autografted along the osteotomy surface site [31].

By osseodensification technique wider implant diameter can be inserted in narrow ridges without creating bone dehiscence or fenestration [4]. Increased insertion [4,29,36] and removal torque values [31,38] have been reported with dental implants placed into osseodensified osteotomies.

The dual use capability of densifying bur in both cutting and noncutting direction may enable the clinician to autograft the maxillary sinus and expands any ridge in maxilla and mandible. Osseodensification facilitates ridge expansion while maintaining alveolar ridge integrity, thereby allowing for total implant length placement in autogenous bone with adequate primary stability and promotes a shorter waiting period to the restoration [27,28].

Conclusion

Preservation of bone bulk during implant osteotomy preparation is crucial for securing primary implant stability, which is highly associated with successful osseointegration and long-term successful clinical outcome. Most of the techniques proposed for implant osteotomy site preparation involve excavation and removal of bone. Recently, a unique; fast and efficient; bone preserving; biomechanical osteotomy preparation technique called osseodensification has been introduced. The osseodensification technique reduces bone sacrifice that appears unavoidable with conventional drilling procedures and prevents fracturing of trabeculae causing a delayed bone growth, as reported with the osteotome technique. The concept of osseodensification has changed the paradigm of implant site preparation and is found to be beneficial in creating a stronger expanded osteotomy for implant placement, through compaction and autografting the surrounding bone particularly in areas with low-density bone. The osseodensification technique is shown to increase the primary stability, the bone mineral density, and the percentage of bone at the implant surface. However, long-term clinical trials and randomized controlled studies are warranted for high level evidence

Conflict of Interest

None declared.

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Volume 2 Issue 12 December 2018