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Review Article

Reverse drilling v/s Conventional drilling: Expounding the concept of osseodensification - A narrative review

Naila Perween[1]*, Shabina Sachdeva[2], Pranav Kapoor[3]

[1]*Dept. of Prosthodontics, Esic Dental College and Hospital, New Delhi, India*
[2]*Dept. of Prosthodontics, Faculty of Dentistry, Jamia Millia Islamia University, University, New Delhi, India*
[3]*Dept. of Orthodontics, Esic Dental College and Hospital, New Delhi, India*

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ABSTRACT

Achieving optimal primary stability during surgical implant placement is essential for successful implant rehabilitation. Several factors, both biomechanical and clinical, influence implant stability. Among these factors, the quality of the surrounding bone and the surgical technique employed play significant roles. *Placement of implants in low density bone such as Type IV bone found in posterior maxilla is a clinical and diagnostic challenge. Low bone density can compromise initial stability and jeopardize the long-term success of the implant.* In order to maintain sufficient bulk and density to achieve the desired bone to implant contact, several surgical techniques have been proposed in such low quality bone. One such innovative technique gaining attention is Osseodensification, which is a non-subtractive drilling technique that utilizes specially designed drills in a counterclockwise direction. This technique is designed to preserve bone integrity while inducing controlled plastic deformation of the surrounding bone. Additionally, Osseodensification facilitates compaction autografting, wherein bone particles are compacted within the osteotomy site, further enhancing primary stability. This review aims to provide insights into the array of techniques available for improving primary stability in low-density bone, with emphasis on the novel Osseodensification procedure.

1. Introduction

Endosseous dental implants have, in the recent past, been considered as the gold standard for rehabilitation of partial and complete edentulism.[1] Achieving osseointegration continues to be the primary requisite for the long term success of dental implants. The most important determinant for osseointegration is perhaps the primary stability achieved during implant placement, which is in turn dependent upon a number of biomechanical and clinical factors such as bone quality and quantity, implant material, design and surface characteristics, presence or absence of systemic diseases or parafunctional habits, as well as the surgical technique employed and operator skills.[2]

The use of Cone Beam Computed Tomography (CBCT) has served as a significant aid in identifying the quality of bone in terms of its density, which is particularly important in areas of low quality bone such as the posterior maxilla.[3] The chances of implant failure tend to be higher in such type IV quality bone, as compared to other classes of bone. Successful implant placement in such low density bone thus, tends to pose a clinical and diagnostic challenge for the operator.[4]

Various adjunctive techniques have been employed in the past in an attempt to improve the primary stability of implants placed in low density bone. Some of these techniques focus on improving implant

* *Corresponding author.*
E-mail address: drnailap88@gmail.com (N. Perween).

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anchorage, while others modify the osteotomy site by altering the conventional implant placement procedure. Osseodensification is one such novel non-subtractive implant preparation technique which works on the principle of bone compaction and auto-grafting, thereby improving implant stability.[5] In contrast to conventional implant drills which work in a clockwise direction, this biomechanical preparation technique uses specially designed drills which rotate in a counterclockwise direction.[6] Osseodensification presents distinct advantages and is hence a subject of further exploration. This narrative review aims to illustrate the various surgical techniques used for implant placement in low density bone with special emphasis on the novel Osseodensification technique.

2. Literature Search and Data Extraction

A comprehensive review of literature was conducted using electronic bibliographic databases such as MEDLINE-Pubmed, SCOPUS & Google Scholar, with the keywords "osseodensification", "dental implant", "primary stability", "osseointegration" and "bone densification". Peer reviewed articles in English language published until July 2021 were retrieved. In vivo and in vitro animal studies, clinical studies, experimental studies, systematic meta-analyses and literature review articles were included. Articles in other languages and on implants other than dental implants were excluded. Full text of the selected articles was thoroughly screened.

3. Discussion

3.1. Increasing primary stability in poor density bone

Primary stability refers to the stability achieved due to the mechanical interlocking of implant threads with the adjacent bone tissue upon insertion of the implant. This is a vital process for healing, as it prevents any micro-movement of the implant during the initial bone remodeling process.[7] Improving the primary implant stability, especially in type IV bone, has been under consistent purview of research and trial. It has been suggested that bone tapping should be avoided while placing implants in low density bone as it may lead to microfractures.[8] Rather, under-sizing the implant has been suggested, as this protocol enhances the osteogenic activity as well as primary stability.[9]

Numerous innovative techniques have been proposed in the past in an attempt to help enhance the primary stability of implants in such low density bone. One such approach is the use of osteotomes for bone condensation, first described by Summers in 1994.[10] Specially designed hand driven condensers and expanders are used to compress the encompassing bone by gradual expansion, aiming to condense bone apically and laterally. However, it has been reported that bone density tends to increase only in the periapical region and not in the entire peri implant area.[11] The increased bone density achieved using this technique may not equate to an increased bone to implant contact(BIC). Also, osseointegration may get delayed as traumatic condensation may lead to trabecular micro-fractures.[8]

The use of bicortical implant anchorage has been proposed as a viable option for implant rehabilitation of partial and completely edentulous arches.[12]This technique has been advocated in medium or low density bone with favourable outcomes.[13] However, this procedure is sensitive to increased stresses and bending forces, which may arise as a result of prosthetic misfit or high occlusal tables, subsequently leading to higher fracture rates.[14]

Another technique meant for enhancing primary stability in low quality bone is the intentional under-preparation of implant bed in an attempt to promote a more frictional insertion of the implant. This is done by selecting the last drill size as one or two sizes smaller than the selected implant diameter. Degidi et al. in their in vitro study, have demonstrated an enhanced primary stability with 10% undersize preparation of implant osteotomy in poor quality bone sites.[15] However, this technique tends to compromise the healing chamber dimensions between sterile bone and implant, thereby decreasing the speed of woven bone filling, in turn affecting secondary implant stability. Also, it may lead to increased chances of pressure necrosis in the crestal region. The use of a stepped approach while preparing undersized osteotomy may help increase implant stability in such cases.[16]

The perpetual demand for techniques attempting to enhance implant stability in low density bone has led to the development of the novel technique of osseodensification, which does not excavate bone tissue per se, but, following the use of specially designed drills, leads to the compaction of bone along the osteotomy site resulting in an improved bone to implant contact (BIC).[6]

3.2. Conventional drilling Vs Reverse drilling

The conventional drilling technique involves the use of standard drills in a clockwise direction to effectively cut and excavate bone tissue for implant placement. The positive rake angles of these drills remove autologous bone. The geometric configuration of such drills is however not proficient enough to create a precise circumferential osteotomy, but tends to result in an elongated and elliptical osteotomy. This reduces torque during implant insertion which can lead to non-integration of the implant. Also, poor quality bone is prone to buccal or lingual dehiscence during osteotomies with conventional drills, thus necessitating additional bone grafting. This not only tends to increase the healing time but also the expense of treatment involved.[17]

In contrast, the novel osseodensification technique densifies the osteotomy site walls centrifugally, by compacting autologous bone immediately in contact, thereby increasing primary stability due to the physical interlocking between the bone and implant. The procedure involves the use of special fluted drills in an anti-clockwise direction which generates rolling and sliding contact, inducing controlled deformation through viscoelastic and plastic mechanisms. The spring back effect generated by residual strains of viscoelasticity creates compressive forces against the implant surface which is the cause for increased bone to implant contact (BIC), as has been demonstrated by Lahens et al. in their experimental study on sheep.[18] It also facilitates the nucleation of osteoblasts on instrumented bone, thus helping enhance the osseointegration process.[19]

3.3. Osseodensification bur design characteristics

For the purpose of non-subtractive osteotomy preparation, Huwais introduced specially designed densifying burs called Densah Burs (Versah, LLC, USA).[20] These burs have a tapered shank along with helical flutes and interposed lands that have a negative rake angle which works the bone chips and debris inward the implant bed rather than removing them. Each flute has a burnishing face to burnish bone and an opposing cutting face which cuts bone when used in the clockwise direction. Besides, these drills have a cutting chisel edge which enables a deeper entry into bone, expands the osteotomy site and compacts the bone along the walls. Atleast one of the lip and land carry an opposing axial reactionary force when rotated clockwise and concurrently advanced inside the osteotomy. This results in a push-back phenomenon, giving the operator an enhanced tactile control.[21] (Figure 1)

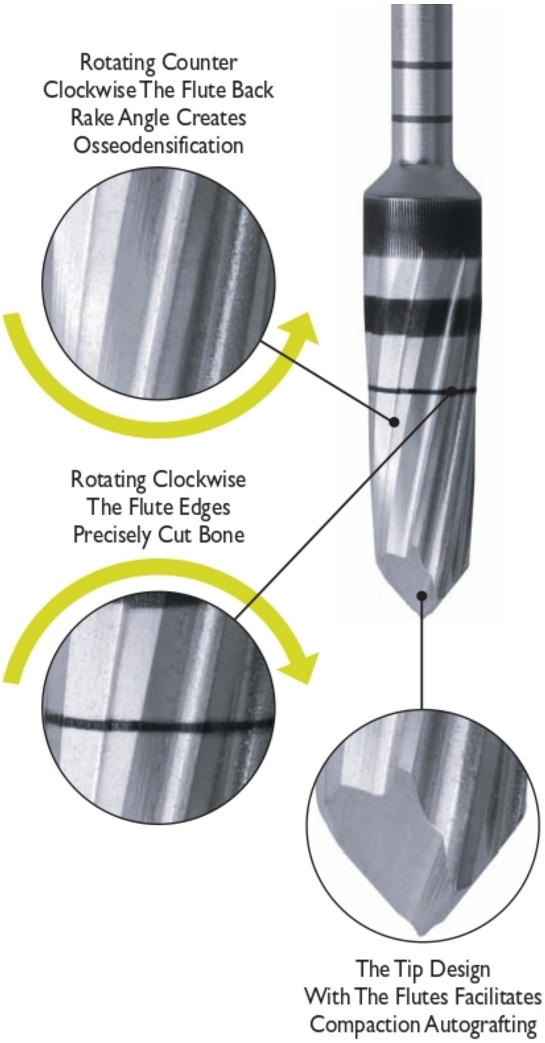

Figure 1: Densah Bur design (Source: Densah^{TM} Bur Surgical Technique Manual, Versah, LLC, Jackson MI, USA. www.versah.com)

3.4. Osseodensification procedure

The osseodensification procedure is initiated by using a drill in the clockwise direction to enter into the bone till the planned depth. Subsequent wider drills are used in a counter-clockwise direction at a speed of 1200 rpm with abundant irrigation, consequently compacting bone apically and laterally along with increasing diameter of the osteotomy site.[19] Copious amount of saline along with bouncing motion of bur is effective in reducing heat generation at the osteotomy site. The saline solution gently pressurizes against the walls, thus generating a rate-dependent strain through a rate-dependent stress induced by the in and out pumping motion. The combined effect increases bone plasticity and causes bone expansion while preserving bone bulk.[22] This also allows a shorter waiting period prior to the restorative phase in contrast to the 12 weeks of waiting required with conventional drills.[23] (Figure 2)

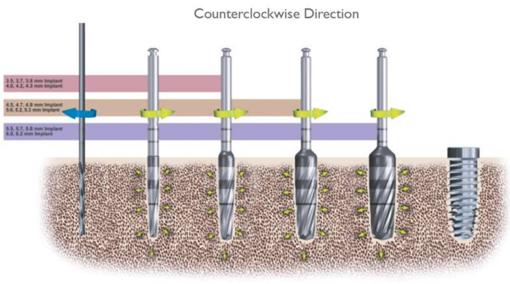

Figure 2: Osseodensification burs used in order of increasing diameter for controlled plastic deformation of bone tissue. (Source: Densah^{TM} Bur Surgical Technique Manual, Versah, LLC, Jackson MI, USA. www.versah.com)

3.5. Biomechanical and histological effects of osseodensification

The amount of bone available adjacent to the osseodensified osteotomy site is reported to be about three times more as compared to the conventional subtractive osteotomy. This is because the non-subtractive osseodensification technique produces a comparatively smaller osteotomy. Huwais & Meyer have reported that the osteotomy diameter may be reduced to as much as 91% of the bur diameter as revealed by micro-CT images following osseodensification. The springy and viscoelastic nature of bone probably contributes to the enhanced bone availability in such cases.[6]

Effective immediate loading of implants necessitates high insertion torque values. It has been claimed that insertion torque value in low density osseodensified sites is approximately double to that achieved with traditional drilling, thereby increasing the primary stability.[6] Comuzzi et al. in their in vitro study on polyurethane foam sheets demonstrated higher insertion torque values by osseodensification procedure in conical implants as compared to cylindrical shaped implants.[24]

Following osseodensification, it has been observed that the non-vital bone debris in the osteotomy site gets remodeled to serve as autografts.[18] This autogenous bone provides nucleation molecules to induce new bone formation, thus enhancing bone density around the implant, increasing its stability in bone, accelerating healing and allowing faster osseointegration.[25]

Bone to implant contact (BIC) and bone area fraction occupancy (BAFO) are parameters that measure successful osseointegration of implant. Sufficient literature evidence is present to support the finding of an increased BIC in osseodensified sites as compared to conventional sites due to the presence of autografted bone. However, as far as BAFO is concerned, statistically significant differences have not been observed between osseodensifed and conventional osteotomy sites.[26,27]

Densah burs facilitate implant placement in narrow ridges without creating bone dehiscence or scarring within the osteotomy walls which removes the necessity of additional grafting. This technique allows alveolar ridge expansion while conserving the ridge integrity and preventing micro-factures in the trabeculae without compromising bone healing.[28]

3.6. Special considerations while using the Osseodensification procedure

As is the case with conventional drilling, osseodensification drills also tend to increase the inherent temperature. However since the procedure compacts bone rather than excavating it, copious irrigation is imperative, without which neighboring osteoblasts may get damaged, resulting in bone necrosis.[29]

Implant insertion torque in osseodensified bone may induce crestal bone micro-fractures. It has thus been recommended to oversize the crestal osteotomy to prevent the implant thread from over-straining during insertion.[19]

This technique must be used with caution in cortical and dense bone since these lack plasticity and have relatively narrow marrow spaces between the bony trabeculae, which allows less bone compaction. Any lateral compression exceeding the viscoelastic limit can lead to weaker bone-implant interface and also induce micro-damage which will require an additional 3 months to repair.[29,30]

4. Conclusion

In conclusion, Osseodensification represents a promising advancement in dental implantology, offering a non-subtractive approach that preserves bone while enhancing osteotomy expansion. The technique's ability to improve bone density and increase the volume around implants is conducive to better bone-to-implant contact and stability, potentially leading to improved clinical outcomes. Though the technique has shown positive results, further, well designed prospective cohorts and long term clinical studies in humans are needed to validate the biological reaction of peri-implant bone and to establish the clinical success of this technique. Additionally, investigations into the histological and biomechanical aspects of osseodensified bone would deepen our understanding of its structural integrity and long-term stability.

In essence, while osseodensification holds great promise as a bone-preserving technique in implant dentistry, its widespread adoption and clinical acceptance hinge on rigorous scientific validation through well-designed clinical studies and evidence-based practice. Only through such comprehensive research endeavors can the true clinical benefits and limitations of osseodensification be fully understood and its role in enhancing dental implant treatment outcomes be established with confidence.

5. Conflicts of Interest

The authors declare no conflicts of interest.

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Author biography

Naila Perween, Tutor https://orcid.org/0000-0003-0110-2108

Shabina Sachdeva, Professor

Pranav Kapoor, Professor

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