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Review Article

The New Bone Drilling Concept- Osseodensification (Hydrodynamic Bone Preparation)

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Abstract

Dental implants are currently accepted as a popular treatment option for the rehabilitation of loss of teeth. Primary implant stability is an essential criteria for achieving successful osseointegration. Primary stability is effected by bone density, implant type and surgical techniques. Increased-insertion torque helps to achieve primary stability. A new concept for osteotomy called osseodensification, a non-extraction technique which become the foremost of changes in implant surgical site preparation. Osseodensification burs, working in a non-subtractive fashion, allow bone condensation and preservation through compaction autografting during osteotomy preparation in lateral direction and increase in the bone implant contact. Osseodensification technique has been proposed to achieve in better osteotomy, bone densification, indirect sinus lift and also attain better ridge expansion. On comparing with conventional implant bed drilling procedure osseodensification has shown advancement in achieving better implant primary stability and osteotomy. The purpose of this review to throw light on the osseodensification concept, mechanism, various procedures and its advantages over the conventional drilling techniques in detail.

Keywords: *Conventional Implant Bed Drilling; Dental Implants; Osseodensification; Osseointegration; Primary Implant Stability*

Abbreviations

BIC: Bone-to-Implant Contact; IT: Insertion Torque; OD: Osseodensification

Introduction

Dental implants are getting popular in these days and become alternative to conventional techniques. The outcome of any implant procedures depends on bone density, implant design and surgical techniques. The implant stability depends on both either mechanical stability, or the biological stability. The insertion torque is directly related to implant primary stability and host bone density [1], High insertion torque could significantly increase the initial bone-to-implant contact percentage (%BIC) compared to implant inserted with low-insertion torque values [2]. The original protocol for the installation of dental implants advocated that the implants remained submerged under soft tissues with no functional loading during healing periods of 3-6 months in order to achieve osseointegration.

Osseointegration is defined as "a direct structural and functional connection between living bone and an implant surface" (Branemark and associates 1977) and is considered an essential factor for implant loading and long-term successful clinical outcome. Osseointegration is commonly affected by the bone to implant contact (BIC) and bone mineral density [3]. Increased primary stability and preserving the bone mineral and collagen material has been shown to enhance the healing process [4,5]. Therefore, it is necessary to preserve bone bulk during the osteotomy preparation site. Drilling is a worldwide osteotomy preparation technique to receive an implant fixture. But, during drilling removal of bone compromises the implant stability and strength. The purpose of this review to throw light on the osseodensification concept, mechanism, procedures and its advantages over the conventional drilling techniques in detail.

Significance of the Study

- The purpose of this review is to emphasize that implant primary stability is strongly influenced by the various surgical techniques, to quote and briefly analyse the various surgical procedures laying weight to the concept of osseodensification.
- This review throw light on a recently develop technique, named osseodensification (OD), to enhance implant stability and long term clinical success.

Primary and secondary stability

Primary stability is positively associated with successful implant integration when there is no micromovement of implant by allowing the mechanically interlock between the bone tissue with implant until secondary stability is achieved.

Implant stability is effected by the bone density, implant type, insertion torque (IT) and the surgical techniques. The biologic stability of the implant known as secondary stability derived from an osseointegrated implant [6]. Primary implant stability has been considered as a signal for future osseointegration. Osseodensification (OD) has recently been introduced, as a new osteotomy technique, which enhances implant stability.

To overcome the deceiving of primary stability uncertainty by Densah® Burs

What is Densah® and Versah® LLC?

Dr. Salah Huwais in 2013 created Densah® Burs which were constructed by Versah® LLC company. Versah® able to provide unique and advance way of preparing osteotomies for implant placement. Verash technology is contradicted to the conventional osteotomy preparations,which involves of removal of bone. His aim was to preserve the healthy bone and make space. This led to the development of the new concept "Osseodensification (OD)" also called as "The Densah Technology by Dr. Huwais".

Osseodensification (OD) is a novel approach in implant dentistry. The procedure is characterized by low plastic deformation of bone that is created by rolling and sliding contact using a densifying bur (Densah™ burs) [7] (Figure 1) that is fluted such that it densifies the bone with minimal heat elevation. Dr. Huwais in 2013 developed a non-extraction technique, with specially designed burs to increase bone density by expanding an osteotomy site [8]. For this motive, he invented specially designed burs called Densah burs (by Versah LLC- The osseodensification company). These burs combine advantages of both speed and tactile control. Standard drills remove and excavate bone during implant site preparation; while osteotomes preserve bone, which tend to induce fractures of the trabeculae that require long remodelling time and delayed secondary implant stability [9]. The Densah burs enable bone preservation and condensation through compaction autografting during osteotomy, which enhance implant stability. Contrary to conventional drills, this drill design creates an environment which increases the primary stability by means of non-subtractive drilling [10].

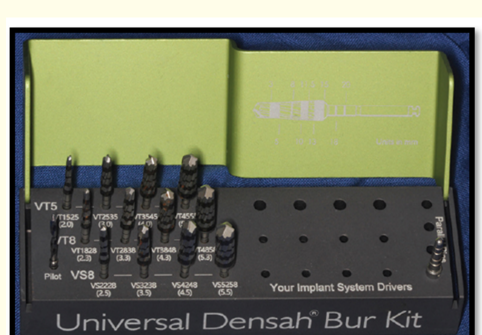

Figure 1: *Versah Kit with densification drills.*

The science behind osseodensification concept

Osseodensification (OD) technique generates a layer of condensed autograft along the surface of the osteotomy site where, there is bone paucity. The compacted, autologous bone immediately in contact with an endosteal device will have higher degrees of primary stability which also facilitate osseointegration [11]. In conventional drills bone remodelling requires more than 3 months to repair the damaged area. Hence, Osseodensification (OD) technique help to reduce the healing period [12].

Features of osseodensification burs [13] (Figure 2)

1. As the bur enters deeper into the osteotomy site this design controls the expansion process because of its conical tapered body.
2. 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.
3. Each helical flute has a burnishing face and an opposing cutting face. When rotated in the burnishing direction this burnishing face burnishes bone and when turned in the cutting direction the cutting face cuts bone.
4. 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 to results in a push-back phenomenon, which provides enhanced control over the expansion procedure.

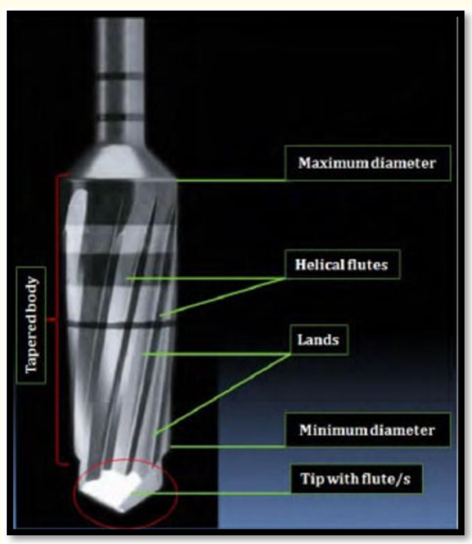

Figure 2: *Features of a densifying bur.*

Technology behind the Densah® burs [14] (Figure 3)

1. These burs have a twist drills or straight fluted drills with four or more lands to guide them through the osteotomy and smoothly compact the bone.
2. It has many lands with a large negative rake angle, which work as non-cutting edges to increase the bone density as they expand an osteotomy in which the displaced bone is compacted and compressed circumferentially. Therefore, increase in biomechanical stability of implant.
3. The pattern of burs have a cutting chisel edge and a tapered shank, so as they easily enter deeper into the osteotomy site, and controls the expansion process.
4. These burs can used as a densify bone by rotating in the non-cutting direction (counter clockwise at 800 - 1,200 rotations per minute) or drill bone by rotating in the cutting direction (clockwise at 800 - 1,200 rotations per minute) [15] (Figure 4).

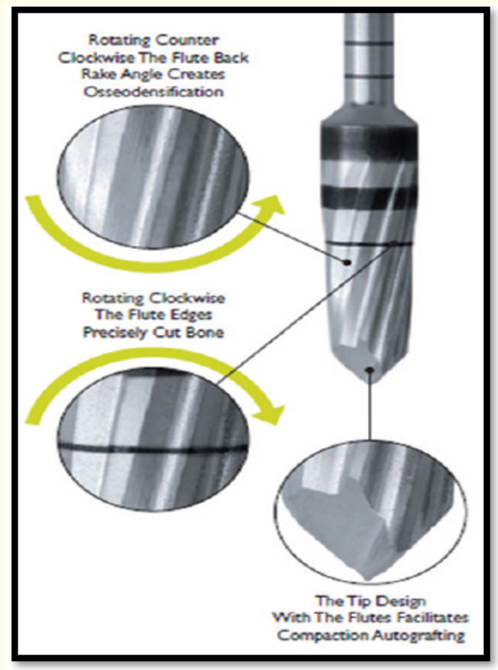

Figure 3: *Role of densification Drills.*

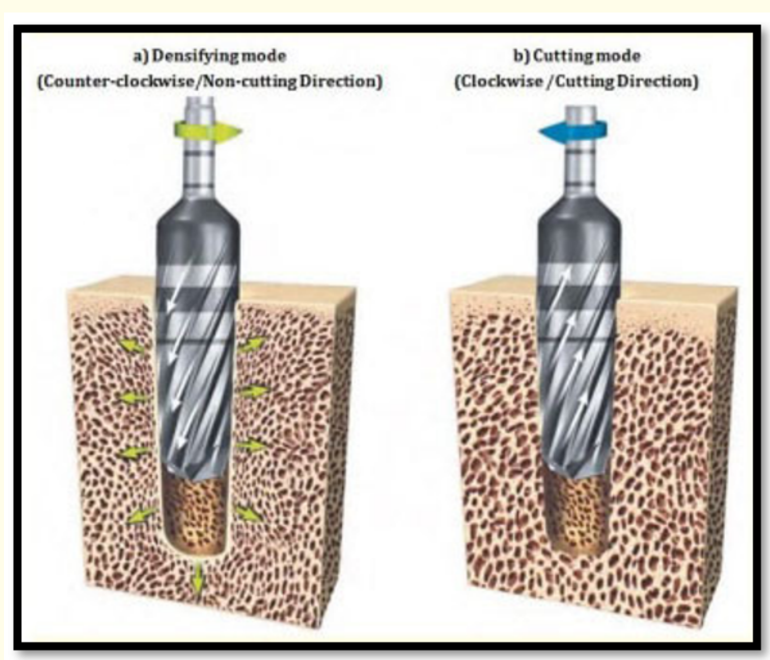

Figure 4: *Dual use of densifying bur- a) Densifying mode- creates osseodensification; b) Cutting mode-precisely cuts bone.*

Mechanism of the osseodensification procedure

In osseodensification (OD) procedure, the densifying burs produce a controlled bone deformation, which allows the expansion of a cylindrical osteotomy without excavating any bone tissue. When the osteotome is removed, the spring-back effect is a response of compacted bone that reduces the osteotomy to a smaller diameter. The spring-back phenomenon is due to the viscoelastic deformation.

To achieve bone compaction Viscoelastic process is used [16]. In this technique , residual strains are created in bone. To increase the bone-to-implant contact (BIC) and primary stability, the residual strain in the bone creates compressive forces against the implant, which promote osteogenic activity [17]. This reverse compression applied to the implant by the bone is responsible for higher removal torques that were generated with osseous densification. High insertion torque is an indication of good primary stability. The bone deformation occurs through viscoelastic mechanisms. Overheating is eliminated by irrigation fluid. This fluid is forced into the osteotomy which facilitate autografting of bone particles along the inner surface of the osteotomy [18].

Osseodensification (hydrodynamic bone preparation) mechanism

Compaction autografting/ condensation

↓

Maintaining bone bulk results in higher Bone to implant contact (BIC)

↓

Enhance bone density

↓

Accelerates bone healing

↓

Increase residual strain

↓

Enhances osteogenic activity through mechanobiology

↓

Increase implant stability

↓

Higher insertion torque

↓

Implant stability Quotient (ISQ) reduces micromotion

Flow chart of Osseodensification Mechanism

Indications [8]

1. It facilitates lateral ridge expansion- Ridge with less than 3 mm of width.
2. It facilitates vertical ridge expansion in maxillary sinus.

Contraindications

1. Patients with various systemic disorders such as compromised immune system, bleeding disorders and titanium allergy should be excluded.

Advantages [19]

1. Increase in bone mineral density.
2. During osteotomy preparation it condense and preserve bone through autografting compaction.
3. Autografting of bony particles, creating a smoother Osseodensification (OD) hole.
4. Primary stability, bone density and bone-implant contact (BIC) are increases.
5. Preserve bone bulk and allow for predictable ridge expansion, at coronal level.
6. Increases residual strain.
7. Higher insertion torque values due to osseodensification result in good prognosis.

Limitations

1. Osseodensification (OD) does not work with cortical bone as cortical bone lacks plasticity.
2. Prevent the densification of xenografts.

Protocol for the use of Densah® bur in different bone qualities in conjunction with clinician experience and judgement (Versah LLC product catalogue, the osseodensification company)

Overview of Densah™ bur kit:

1. Kit is designed with 12 burs to create osteotomies.
2. Each Densah™ Bur is marked from 8 - 20 mm depth.
3. In dense bone, Densah™ Burs are designed in small increments (alternate between VT5 and VT8).
4. In soft bone, the osteotomy should be prepared by Densah™ Bur with an average diameter 0.5 - 0.8 mm.
5. In hard bone, the osteotomy should be prepared with Densah™ Bur with an average diameter 0.2 - 0.5 mm.

Protocol I- Osseodensification facilitates medium and soft bone density

1. Implant was placed and buried under the soft tissue using the technique indicated.
2. By using the Pilot Drill (Clockwise drill) at speed of 800 - 1500 rpm with copious irrigation, drill to the desired depth.
3. Begin with the narrowest Densah™ Bur.
4. Change the drill motor to reverse (Counterclockwise) direction at speed of 800-1500 rpm.
5. Running the bur into the osteotomy site in a densifying direction.
6. When there is a feeling of the bur pushing up out of the osteotomy, modulate pressure with a pumping motion to achieve desired depth.
7. Ample irrigation is always required.
8. When there is a feeling of resistance, increase the pressure and the number of bouncing-pumping motions to achieve desired depth.
9. Placement of the implant.
10. Placing the implant with a torque indicating ratchet wrench to the desired depth.

Protocol II- Osseodensification in dense bone quality in the mandible

1. Implant was placed and buried under the soft tissue using the technique indicated.
2. It is advised to prepare the osteotomy 1.0 mm deeper than the final implant length.

3. Begin with the narrowest Densah™ Bur (2.0).
4. Change the drill motor to reverse (Counterclockwise) direction at speed of 800-1500 rpm with irrigation.
5. Running the bur into the osteotomy site in a densifying direction.
6. When there is a feeling of the bur pushing up out of the osteotomy, modulate pressure with a pumping motion to achieve desired depth.
7. In very dense bone, strong resistance may be felt.
8. Change the drill motor to forward-Cutting Mode (Clockwise) direction at speed of 800-1500 rpm.
9. Begin running the bur into the osteotomy.
10. To densify and auto-graft the cut bone back into the osteotomy walls change the drill to reverse-densifying mode.
11. Re-deposit the cut bone particles inside the osteotomy by not eliminating the bur between cutting and densifying modes.

Protocol III- Osseodensification facilitates lateral ridge expansion

Ridge expansion procedure

1. Implant was placed and buried under the soft tissue using the technique indicated for the implant position.
2. By using the Pilot Drill (Clockwise drill) at speed of 800-1500 rpm with copious irrigation, drill to the desired depth.
3. Begin with the narrowest Densah™ Bur.
4. Change the drill motor to reverse-Densifying mode (Counterclockwise) direction.
5. Begin advancing the bur into the osteotomy.
6. When there is a feeling of the bur pushing up out of the osteotomy, modulate pressure with a pumping motion to achieve desired depth.
7. The Bone will slowly expand as the bur diameter increases.
8. Placement of the implant into the osteotomy.
9. Placing the implant with a torque indicating ratchet wrench to the desired depth.
   I. To place a 3.7 mm/4.0 mm implant fixture, a minimum of 3.0 mm of alveolar ridge width is required.
   II. To place a 4.7 mm/5.0 mm implant fixture, a minimum of 4.0 mm of alveolar ridge width is required.
   III. To place a 5.7 mm/6.0 mm implant fixture, a minimum of 5.0 mm of alveolar ridge width is needed.
   IV. If less than 1.0 mm buccal bone plate thickness, bone grafting is recommended.

Guided expansion graft

Indicated for cases with less than 3.0 mm ridge width

1. Implant was placed and buried under the soft tissue using the technique indicated for the implant position.
2. By using the Pilot Drill (Clockwise drill) at speed of 800-1500 rpm with copious irrigation, drill to the desired depth.
3. Begin with the narrowest Densah™ Bur.
4. Change the drill motor to reverse-Densifying mode (Counterclockwise) direction.
5. Running the bur into the osteotomy.
6. When there is a feeling of the bur pushing up out of the osteotomy, modulate pressure with a pumping motion to achieve desired depth.
7. For reaching a final width of 3.5 - 4.0 mm increase osteotomy diameter in small increments.
8. The bone will slowly expand as the bur diameter increases.
9. To achieve primary closer, graft the newly formed socket with bone graft materials and membranes.

Protocol IV- Osseodensification facilitates vertical ridge expansion

Maxillary sinus autografting

1. Implant was placed and buried under the soft tissue using the technique indicated for the implant position.
2. In cases where posterior residual alveolar ridge height is ≥ 7.0 mm, drill to the depth determined within an approximate of 1.0 mm from the sinus floor using a pilot drill.
3. With the help of radiograph confirm pilot drill position.
4. Begin with the narrowest Densah™ Bur.
5. Change the drill motor to reverse-Densifying Mode (Counterclockwise drill speed 800-1500 rpm with copious irrigation).
6. Begin advancing the bur into the osteotomy site.
7. When there is a feeling of the bur reaching the dense sinus floor, modulate pressure with a pumping motion to advance past the sinus floor.
8. Maximum advancement past the sinus floor must not exceed 1.0 mm.
9. With the help of radiograph confirm the first Densah™ Bur vertical position.
10. As the next Densah™ Bur advances in the osteotomy, bone will be pushed toward the apical end and will begin to gently lift the membrane and autograft compacted bone.
11. To achieve additional vertical depth and maximum membrane lift of 3.0 mm (in 1.0 mm increments) use the burs in Densifying Mode.
12. Placement of the implant into the osteotomy.
13. Placing the implant with a torque indicating ratchet wrench to the desired depth.

Protocol V- Instructions for maintenance of Densah™ burs kit

- **Stage 1: Cleaning:** Drills should be brushed and rinsed with detergent to remove any remaining blood or tissue.
- **Stage 2: Ultrasonic Cleaning**: Drills should be cleaned in an ultrasonic bath using appropriate enzymatic detergent (10% solution).
- **Stage 3: Rinsing:** Drills should be rinsed with running water to completely remove detergent and then dried.
- **Stage 4: Sterilization:** Drills should be sterilized in an autoclave at 132°C (269.6°F) at a pressure of 315 Kpa for a 4-minute.
- **Stage 5: During Use:** Drills should be soaked in a sterile saline solution.
- **Stage 6: Storage:** Burs can be used immediately upon opening after long-term storage.

Effect of osseodensification on bone density [20]

The osseointegration leads to bone formation on the implant surface and contributes to implant secondary implant stability. In low bone density areas, the insufficient bone could affect primary and secondary implant stability. A layer of increased bone mineral density has been shown around the periphery of osteotomies using osseodensification (OD). The increase in bone density achieved by osseodensification (OD).

Comparison between osseodensification and conventional drilling technique [13]

Technique	Osseodensification technique	Conventional 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: *Comparison between osseodensification and conventional drilling technique.*

Healing of the osteotomy by osseodensification technique

The most specific feature of the healing pattern is observed at the level of coronal area where, the bone presented an granular aspect. In these zones, the bone trabeculae shows outer side lamellar bone layers and the specific granular layer in the inner side. The percentage of bone surface lined by osteoid bands in the coronal area is much higher than that found in other areas of the implants. The increase of bone density is particularly evident in the most coronal implant region. Active bone remodeling is found to be directed more toward bone apposition and bone density increase than toward bone resorption [21]. This suggests that, in the long run, the bone could still increase its density.

Discussion

Lahen B., *et al*. conducted a study to examine the effect of osseodensification (OD) on the primary stability and early osseointegration of implants and results showed that the osseodensification (OD) drilling technique significantly enhanced insertion torque (IT) values. After six weeks in histometric results suggested that the experimental groups drill design positively influenced osseointegration when utilised in both clockwise or counter-clockwise osseodensification (OD) directions. Thus, they concluded that regardless of the design of implant, the osseodensification (OD) drilling technique enhanced the primary stability and bone to implant contact (BIC).

Trisi P., *et al*. evaluated the efficacy of osseodensification (OD) technique to enhance bone ridge density, width and implant secondary stability. They conducted a biomechanical and histological analysis after inserting 20 implants in the iliac crest of two sheeps and using conventional drill for implants on one side as control and osseodensification (OD) for implants on the other side as test group. They reported a significant increase in ridge width and bone volume in the test group. This increase of bone density in the osseodensification (OD) site was said to be evident in the most coronal implant site where the bone trabeculae were thickened because of incorporation of autogenous bone fragments during healing.

Huwais S and Meyer E were observed that osseous densification increased the insertion torque compared to standard drilling. High insertion torque significantly increase the initial bone to-implant contact (BIC %) and was found to be directly related to implant primary stability and host bone density [22].

Alghamdi H., *et al*. conducted a study where, the osseodensification (OD) technique increased the insertion torque (IT) of implants to 49 Ncm approximately in low density bone when compared to 25 Ncm in standard conventional drilling technique. According to them, the osseodensified osteotomy diameter was reduced to viscoelastic deformation nature. This spring back effect of bone due to viscoelasticity in osseodensification (OD), causes residual strains which create compressive forces against the implant surface, thereby enhancing the bone to implant contact (BIC) and primary stability.

Lopez CD., *et al*. conducted a study to assessed the biomechanical and histological effects of osseodensification (OD) surgical instrumentation in a spine model animal study and concluded that this technique can potentially improve the safety and success rates of bony drilling at all sites of low bone density and limited bone volume.

Conclusion and Future Perspective

Most of the techniques suggested for implant osteotomy involve removal of bone. Osseodensification (OD) has recently been introduced, as a new osteotomy technique, which enhances implant stability. This technique reduces bone sacrifice that appears inevitable with conventional drilling procedures. The concept of osseodensification (OD) has changed the prototype of implant site preparation and is found to be beneficial in creating a stronger expanded osteotomy for implant placement, through compaction and autografting. This technique is shown to increase the primary stability, bone mineral density, and the percentage of bone at the implant surface. The healing process will be enhanced by preserving the bone bulk. Current literature evidence is inadequate to draw any concrete conclusion, and more long-term clinical trials and randomized controlled studies are recommended in this field for high level evidence.

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Author Contributions

Neelam Das, was contributed to update all relevant information to formulate the design, drafted the manuscript review. The author gave final approval and agree to be accountable for all aspects of the work.

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Conflicts of Interest

There are no conflicts of interest.

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