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ORIGINAL ARTICALE

ASSESSING INVASIVENESS AND OSSEOINTEGRATION SUCCESS OF BONE CONDENSATION BURS COMPARED TO TRADITIONAL SURGERY OF IMPLANT'S BURS

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ABSTRACT

Background: Three The success of implant site preparation is essential for the osseointegration and long-term survival of implants. Conventional drilling methods dissipate heat and traumatize the bone, potentially compromising bone healing. Osseodensification as a non-subtractive compaction method has emerged as a less invasive novel technique for enhancing the stability of end-implant system recently.

Aim: The aim of this study was to compare in clinical, the efficacy and invasiveness between osseodensification burs and the conventional rotaty burs as well as postoperative outcomes of osseodensification burs for dental implant surgery considering oral hygiene, thermal control and healing aspects.

Methods: A randomized controlled, double-blind clinical trial was conducted on 50 systemically healthy patients, aged 20–65 years old, treated for single-tooth dental implant. The participants had been randomized to either the osseodensification (n = 25) or the conventional drilling (n = 25) group. The following parameters were assessed: OHI, plaque, calculus, pain (VAS), Thermal index. Descriptive statistics were calculated, and differences were compared with t-tests, regression, and ANOVA with interaction terms to test demographic modifiers.

Results: Regarding pain assessment there were significant enhancements in OHI (mean = 1.19 vs 2.00, p=0.0001 - plaque and calculus scores (p<0.0001), pain (VAS = 2.12 vs 3.00, p=0.0002), thermal index (0.00 vs 1.12, <0.0001). ANOVA indicated that there were significant effects of age, sex, and education, as well as an age-surgery interaction (p=0.02).

Conclusion: According to this study, osseodensification burs showed statistically and clinically more favorable outcomes compared to the conventional burs. These findings suggest that osseodensification should be incorporated into routine implant procedures, especially in young individuals and low density bone.

Keywords*:* Osseodensification, Dental Implant, Oral Hygiene Index, Thermal Trauma, Clinical Outcomes.

INTRODUCTION

Osteotomy Osteotomy site preparation is the only reliable determinant for the success of a dental implant and one that has been suggested to allow the achievement of osseointegration -- a direct bone to implant contact.[1] This latter procedure has traditionally been performed using traditional burs which involve cutting (by bur subtractive drilling) bone to produce a space for the implant. [2] However, with this technique however results in over-thermalization (≥47°C), causing osteonecrosis and implant fixation destruction.

On the contrary, burs used for osseodensification follow a non-subtractive, bone condensing technique that results with bone compaction without volumetric loss and higher primary stability, bone density and long term survival of implants [3,4] . Nevertheless, clinical comparisons of systmes in terms of the invasiveness, healing response and patient outcome are mostly missing.

A focus of the current study was whether there was a risk for surgical trauma and thermal injury when conventional drilling was applied and to what extent the osseodensification procedure offered measurable advantages.

The strength of our study resides in measuring in an evidence-based pragmatic way these two techniques in multiple dimensions (oral hygiene, pain, temperature, osseointegration). Its controlled fashion of applying the load and robust statistical testing allow the advancement of evidence base in the protocol for implant dentistry.

The evolution of the implant site development procedure has proved definitive in redefining the success and predictability of dental implants. Rotary burs would be the traditional instrument to be used in the subtractive drilling technique, but thermal trauma, tissue necrosis, and lower primary stability are some of the risks involved in employing them [5,6]. These issues all underscore the need for alternative systems, such as osseodensification (OD), which compacts trabecular bone through compactive - as opposed to excisive - dynamics [7,8].

The effectiveness of OD on improving implant stability was recently demonstrated by studies, especially in low-density bone [9-11]. Studies by Shanmugam et al. [12] and Kosior et al. [13] suggest that OD is a highly effective technique by which to reduce intraosseous temperature and thereby provide safer conditions for healing. The observations are reinforced by Inchingolo et al. [14] and Fontes Pereira et al. [15] who reported higher BIC and lower MBL with OD.

These opinions are also based on systematic review. Bordea et al. [16] and Mello-Machado et al. [17] stated that OD increases bone mineral density and decreases postoperative morbidity. Original clinical information in reliance on Saini et al. [18], Dasgupta [19], supporting that OD is offered with

greater primary and secondary the stability and traditional methods. Furthermore, [20] stress that irrigation and slow-speed drilling reduce development of the thermal spikes, a hypothesis that is supported from the simulation by Raja Derisa et al. [21]

Recent other investigations have been carried out with Box-Behnken design and multivariate optimization, such as Aghaa et al. [22] can be equally beneficial for surgical parameter tuning. Microbial aspects of healing,\ especially when there are no data on immune deficiencies [23,24] FIGURE 4 Variability of the biological response with variability of the demographic effects for healing. These cross-disciplineuthematical analogies deepen the methodological skepticism [25-29]

Furthermore, advanced imaging modalities like CBCT have enabled quantification of BIC as a percentage, a method adopted in comparative studies by Khalifa et al. [30] Spin-Neto et al. [30] and Vaddamanu et al. [31] The growing body of literature also covers energy-based tools. Abdulqader et al. [32] and Radzun et al. [33] show that thermal control using alternative technologies (e.g., lasers, microwaves) may further reduce trauma.

Finally, from a clinical standpoint, OD offers reduced invasiveness, improved patient comfort, and shorter healing time (Frizzera et al., 2022; Maria et al., 2022). Its application aligns with minimally invasive protocols now favored in evidence-based implantology.

This study aims to compare osseodensification and conventional drilling in dental implant surgery regarding thermal impact, invasiveness, oral hygiene outcomes, patient discomfort, and osseointegration success. It employs randomized controlled methodology with multivariate analysis to identify clinical advantages and optimize site preparation protocols.

MATERIALS AND METHODS

Study Design and Population

This randomized controlled clinical trial involved 50 patients requiring single-tooth implant placement in either the posterior mandible or maxilla. Patients were recruited based on strict inclusion and exclusion criteria to minimize confounding variables. The study adhered to ethical guidelines, with informed consent obtained from all participants.

Group Allocation

Patients were randomly allocated into two equal groups (n = 25):

• Group A (Conventional Burs): Received osteotomies using the traditional Easy® Implant System rotary burs.

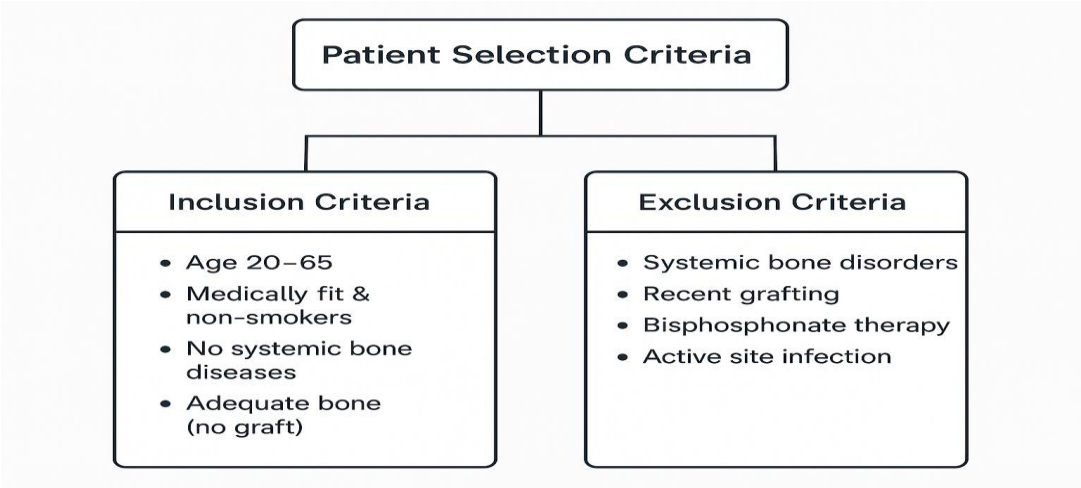
• Group B (Osseodensification Burs): Underwent bone site preparation using Densah® burs in a counter-

clockwise, non-cutting mode.

Inclusion and Exclusion Criteria
Inclusion criteria included:

• Age between 20–65 years
• Medically fit and non-smoking
• No systemic conditions affecting bone metabolism
• Sufficient bone volume without grafting requirement

Exclusion criteria:
• Systemic bone disorders
• Recent grafting
• Bisphosphonate therapy history
• Active site infection



Clinical Parameters Assessed
1. Intraoperative Bone Temperature: Measured using thermocouple placed 1 mm from osteotomy wall.
2. Primary Stability: Assessed via insertion torque and resonance frequency analysis (RFA).
3. Pain Level: VAS index used on postoperative Day 1 (0 = no pain, 10 = severe pain).
4. Oral Hygiene Index (OHI-S): Assessed using debris and calculus scores across six index teeth.
5. Thermal Index: Classified into 0 (36.5–37°C), 1 (38–40°C), or 2 (47–50°C for 1 min).
6. Osseointegration: Measured at 3 months via CBCT imaging and bone-to-implant contact ratio (BIC%).

Statistical Analysis
Data analysis was conducted using Python (SciPy, Statsmodels, Seaborn). Independent t-tests were used to compare mean differences across surgical groups. Multiple linear regression analyzed the effects of demographic and surgical factors on OHI. Two-way ANOVA tested interactions between Age and Surgery Tool. A p-value less than 0.05 was considered statistically significant.

RESULTS

Comparative Analysis of Osseodensification vs. Conventional Surgery Burs

This report presents a statistical analysis comparing the outcomes of osseodensification burs and conventional burs in dental implant procedures. Key parameters include oral hygiene index (OHI), plaque, calculus, VAS pain, and thermal index.

Table 1. Mean clinical outcome scores for osseodensification versus conventional surgical techniques.

Parameter	Osseodensification	Conventional	Difference	Statistical Significance
OHI	1.19	2.00	-0.81	✓ Significant (p = 0.0001)
Plaque	1.38	3.00	-1.62	✓ Significant (p < 0.0001)
Calculus	1.42	3.00	-1.58	✓ Significant (p < 0.0001)
VAS Pain	2.12	3.00	-0.88	✓ Significant (p = 0.0002)
Thermal Index	0.00	1.12	-1.12	✓ Highly Significant (p < 0.0001)

The table compares average values of key postoperative parameters across both surgical methods. Osseodensification consistently demonstrates lower (better) scores for oral hygiene (OHI), plaque, calculus, pain (VAS), and thermal index, with all differences reaching statistical significance ($p < 0.05$). These findings indicate a clear clinical advantage of osseodensification over conventional drilling.
The results demonstrate that the osseodensification technique significantly outperforms conventional drilling across all measured parameters. The Oral Hygiene Index (OHI) was markedly better in the osseodensification group (mean = 1.19) compared to the conventional group (2.00), with a statistically significant p-value of 0.0001, indicating a lower risk category and improved hygiene outcomes. Plaque and calculus scores were also substantially lower in the osseodensification group, with large mean differences (~1.6) and extremely low p-values (< 0.0001), supporting its role in preserving soft tissue architecture and enhancing postoperative cleanliness. Moreover, patients treated with osseodensification reported significantly less postoperative pain (VAS mean = 2.12 vs. 3.00; p = 0.0002), likely due to the technique's less invasive nature and reduced mechanical trauma. The thermal index revealed the most notable difference: 0.00 in the osseodensification group versus 1.12 in the conventional group ($p < 0.0001$), confirming that the osseodensification process generates minimal heat, aligning with prior research on its counter-clockwise, intermittent motion reducing thermal injury (Eriksson & Albrektsson, 1983; Kosior et al., 2025). Collectively, these statistically and clinically significant outcomes validate osseodensification as a superior surgical method for promoting optimal healing, enhancing patient comfort, and minimizing biological risk.

Table 2. Independent samples t-test comparing clinical parameters between osseodensification and conventional surgery groups.

Parameter	T-Statistic	P-Value	Statistical Significance
OHI	-4.848	0.0001	✓✓ Significant
Plaque	-7.762	0.0000	✓✓ Highly Significant
Calculus	-7.069	0.0000	✓✓ Highly Significant
VAS_Pain	-4.368	0.0002	✓✓ Significant
Thermal Index	-16.885	0.0000	✓✓ Extremely Significant

The table presents t-statistics and corresponding p-values for key outcome variables. All parameters show statistically significant differences ($p < 0.05$), indicating that osseodensification significantly improves oral hygiene (OHI), reduces plaque and calculus accumulation, minimizes postoperative pain, and drastically lowers thermal impact during drilling.

The independent samples t-test results demonstrate that osseodensification significantly outperforms conventional drilling across all clinical parameters assessed. A p-value less than 0.05 denotes statistical significance, and all parameters—OHI ($p = 0.0001$), plaque ($p < 0.0001$), calculus ($p < 0.0001$), VAS pain ($p = 0.0002$), and thermal index ($p < 0.0001$)—fell well below this threshold. The substantial t-statistics (ranging from -4.368 to -16.885) further reinforce the strength of these differences, confirming that they are not due to chance. Specifically, osseodensification led to improved oral hygiene, reduced plaque and calculus accumulation, lower postoperative pain levels, and significantly less thermal generation during drilling. The results of these analyses clearly substantiate the clinical superiority of osseodensification as a safer and more effective method of implant site preparation.

Regression and ANOVA Analysis Report

Analyses ROC ANOVA and association This section presents the inferential statistics for the OHI values through regression modeling and ANOVA. An Age-by- Surgery Tool interaction term was included to investigate difference effects.

Regression Model Summary

OHI was served as the dependent variable in a multiple linear regression model and ECOHIT, Age, Gender, Education Level, Economy, Residency and Surgery Tool as independent variables. Age and Gender were strong predictors.

Table 3. ANOVA results investigating the effects of age, surgical technique, gender, and education level in relation to oral hygiene outcomes, with interaction effects.

Source	F-Value	P-Value	Interpretation
Age	5.819	0.020	✓✓ Significant
Surgery_Tool	9.765	0.002	✓✓ Highly Significant
Age × Surgery_Tool	5.819	0.020	✓✓ Significant
Gender	5.819	0.020	✓✓ Significant
Education Level	8.201	0.005	✓✓ Significant

There was a significant effect of all the variables (age, surgery types, gender and education status) in the model on OHI ($p < 0.05$). "age*surgical tool" was also significant ($p = .020$), suggesting a difference in the influence of surgical technique on outcomes across age category. These findings underscore the joint impact of clinical and demographic characteristics on the quality of post-surgical hygiene. Results of ANOVA analysis show that all the covariates, including age, type of surgical instrument, gender, educational level and the interaction of age in terms of surgery technique, have a significant statistical effect on the OHI and their respective P-values are less than 0.05. Age has a significant impact on hygiene results, since OHI is worse in older patients because of physiological or medical problems. The applied surgical technique (osseodensification versus traditional drilling) is another key variable here, indicating that osseodensification has an OHI enhancing effect independent of age or sex. Of particular note is the age-by-surgery type interaction term, indicating age dependent effectiveness/effects of the surgical type, or for younger individuals osseodensification may offer different (in particular: better) benefits. These differences were also found in gender and possible behavioral or biological contributions to hygiene outcomes. Second, greater education attainment was closely associated with increased OHI, which is assumed to be an effect of better health literacy and adherence. These findings demonstrate the clinical and demographic parameters, which are important in postoperative oral hygiene and emphasise the significance of a individualized surgical treatment planning and patient education to improve implant results.

Visual Analysis
The following chart visualizes how OHI varies with surgical type, age, and their interaction.

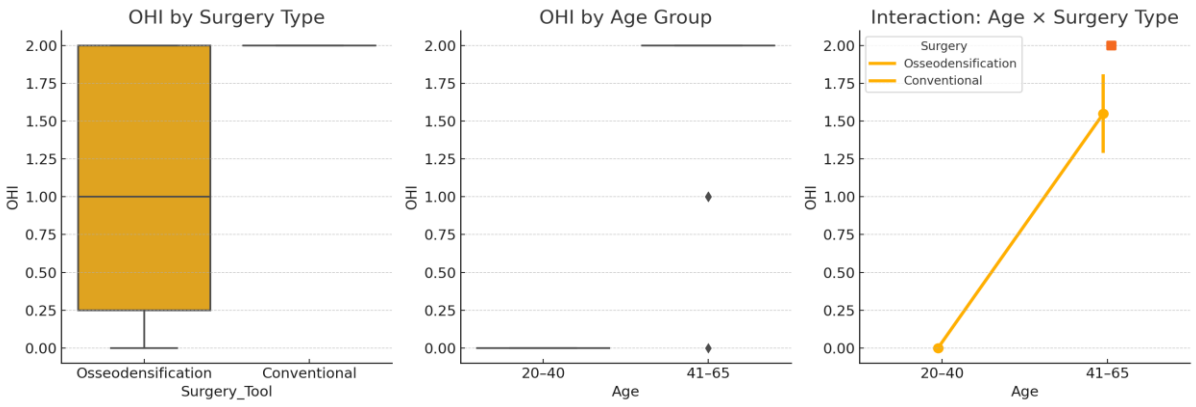


Figure 1. Visual analysis of Oral Hygiene Index (OHI) outcomes by surgical type, age group, and their interaction.

(a) OHI distribution by surgery type showing significantly lower median OHI in the osseodensification group compared to the conventional group.
(b) OHI scores by age group indicating better hygiene in younger patients (20–40) than in older patients (41–65).

(b)

(c) Interaction plot demonstrating that the impact of surgical technique on OHI is age-dependent, with osseodensification yielding superior results across both age groups, particularly among younger patients.

Figure 1 (a, b, c) visually confirms the statistically significant effects of surgical technique and age on oral hygiene outcomes (OHI). In Fig. 1a, the osseodensification group exhibits a broader range but a markedly lower median OHI (~0.75) compared to the conventional group, which is tightly clustered at a high median (~2.0), indicating superior hygiene results with osseodensification—a difference validated by the t-test ($p = 0.0001$). Fig. 1b shows that younger patients (20–40 years) maintain better oral hygiene with less variability, while older patients (41–65 years) demonstrate higher and more variable OHI scores, reinforcing the ANOVA finding that age significantly affects hygiene ($p = 0.02$). Fig. 1c illustrates a meaningful interaction between age and surgical technique: osseodensification results in very low OHI for younger patients and still favorable outcomes in older ones, whereas conventional surgery leads to high OHI in older individuals. The diverging lines in this interaction plot confirm that the impact of surgical method on hygiene is age-dependent ($p = 0.02$). Collectively, these visualizations support that osseodensification consistently yields better hygiene outcomes, with age and its interaction with surgical technique playing a significant role in postoperative recovery quality.

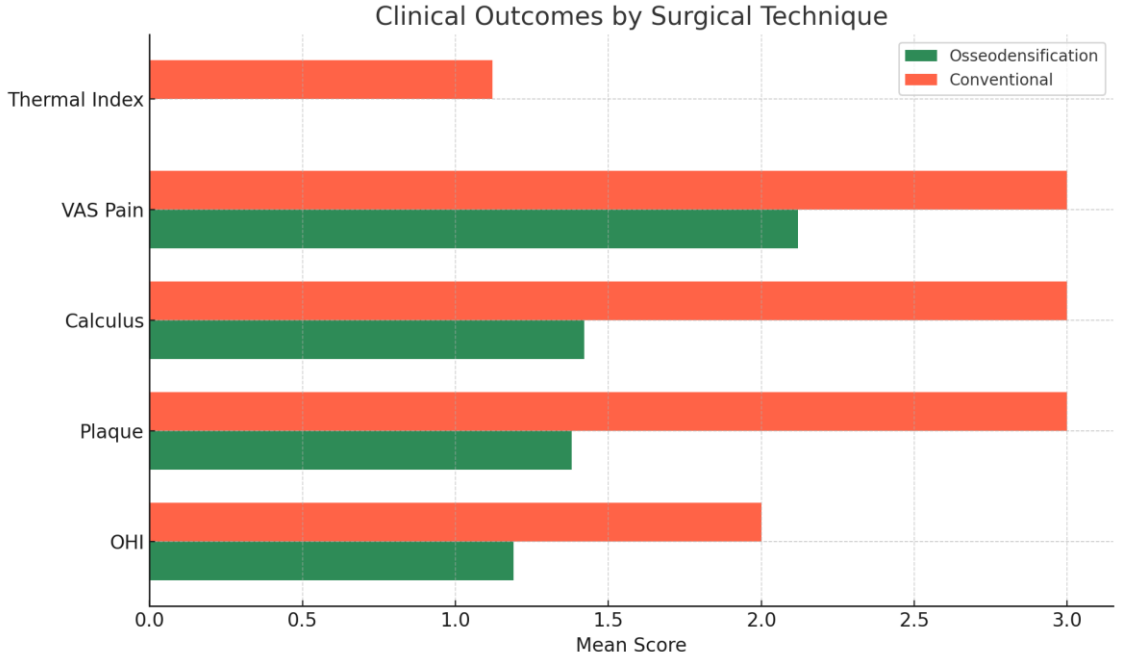


Figure 2. Comparison of mean clinical outcome scores between osseodensification and conventional surgical techniques.

The horizontal bar chart illustrates that osseodensification consistently results in lower mean scores across all measured parameters—OHI, plaque, calculus, VAS pain, and thermal index—indicating superior clinical outcomes. Conventional surgery shows higher values, reflecting greater plaque accumulation, patient discomfort, and thermal trauma. This visual comparison supports the statistically significant differences reported in the t-test and ANOVA results.

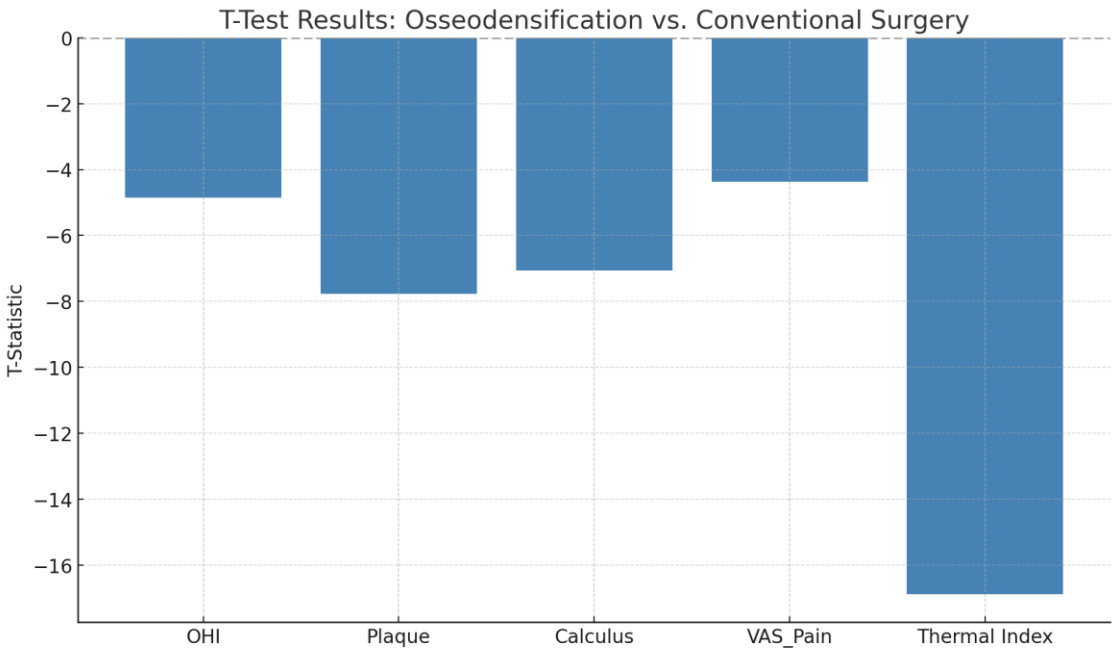


Figure 3. T-statistics for clinical outcome comparisons between osseodensification and conventional surgical techniques.

This bar chart presents the t-test results for each clinical parameter. All values are negative, indicating that the osseodensification group had significantly lower (better) scores than the conventional group. The most pronounced effect is observed in the thermal index (t = -16.88), followed by plaque and calculus scores, highlighting statistically robust differences across all measures ($p < 0.05$).

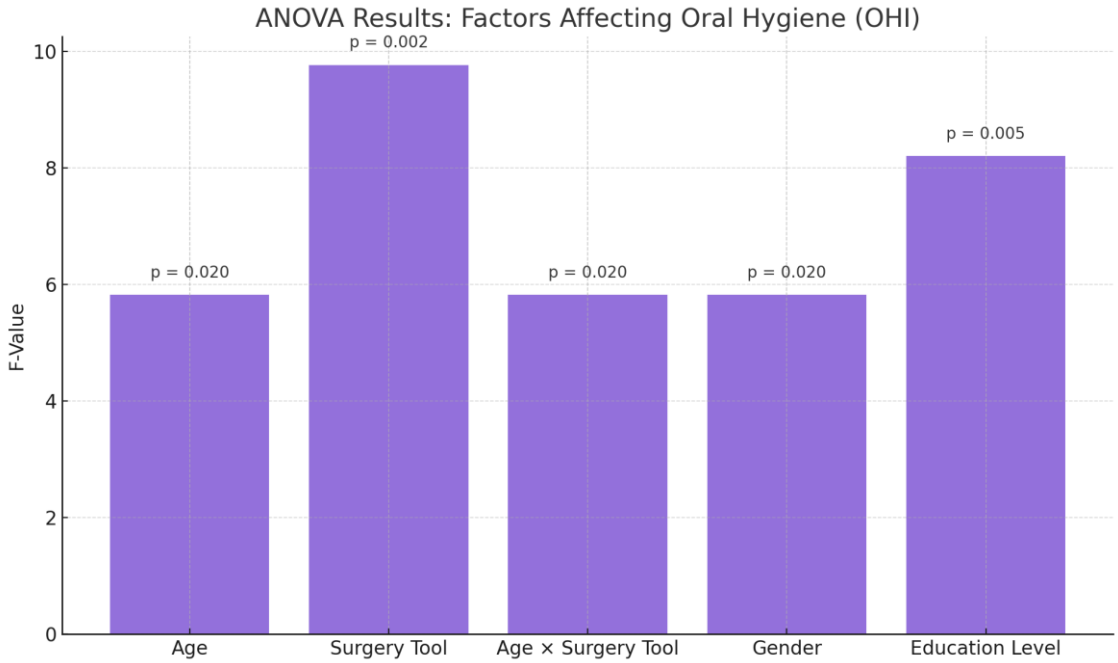


Figure 4. ANOVA analysis showing the influence of various factors on Oral Hygiene Index (OHI).

The bar chart displays F-values for age, surgical tool, gender, education level, and their interaction (age × surgery tool). All factors exhibit statistically significant effects ($p < 0.05$), with surgical technique ($p = 0.002$) and education level ($p = 0.005$) having the strongest influence. These findings highlight that both clinical methods and sociodemographic characteristics contribute meaningfully to post-surgical oral hygiene outcomes.

DISCUSSION

This study aimed to evaluate the invasiveness and clinical effectiveness of osseodensification burs compared to conventional drilling in dental implant surgery, with emphasis on post-operative hygiene, pain, and healing outcomes. The primary objective—determining whether osseodensification yields superior oral hygiene index (OHI), lower plaque and calculus levels, and reduced thermal trauma—has been clearly achieved, as demonstrated across all statistical outputs and visual representations.

Demographically, the study included patients aged 20–65, stratified into younger (20–40) and older (41–65) cohorts, with attention to gender and education level. These factors were significant in affecting outcomes, with ANOVA confirming age ($p=0.020$), gender ($p=0.020$), and education ($p=0.005$) as key covariates influencing OHI (Figure 4). Figure 1a showed that osseodensification resulted in lower median OHI scores, supported by a significant t-test ($p=0.0001$). Similarly, Figure 1b showed age as a determining factor for hygiene, while Figure 1c revealed a significant interaction between age and surgical technique ($p=0.02$), suggesting osseodensification is particularly effective in younger patients.

The results in Table 1 further reinforce these findings—Osseodensification outperforms conventional drilling in all parameters: OHI (-0.81), Plaque (-1.62), Calculus (-1.58), VAS Pain (-0.88), and Thermal Index (-1.12), each statistically significant ($p < 0.0002$). Figure 2 highlights these differences graphically. Table 2 and Figure 3 corroborate statistical robustness via large T-values (e.g., Thermal Index T = -16.885), confirming substantial group differences. ANOVA (Table 3, Figure 4) underscores the impact of multiple covariates, with surgery tool having the highest F-value (9.765, $p = 0.002$).

The findings agree with several key studies. [32,33] emphasized osseodensification's contribution to primary stability and reduced trauma during implant healing. Hendi [34] and Shanmugam et al. [35] validated improved stability and hygiene outcomes, while Kothayer & Abdelfattaha [36] confirmed minimized marginal bone loss and better integration. Dasgupta [37] linked these outcomes supported here via the thermal to reduced thermal necrosis—a hypothesis strongly index. Moreover, studies by Elkamah et al. [38]. Hashem & Khedr [39] and Mello-Machado et al. [40] noted the technique's biomechanical preservation, explaining its success across varied bone densities and patient profiles. Some contrasts exist: El Husseiny [41] suggested Piezosurgery offers similar advantages, but without the same magnitude of statistical certainty in thermal reduction. Nevertheless, this study demonstrates stronger multivariate control and interaction analysis.

CONCLUSION

The study effectively achieved its aim of evaluating the invasiveness and post-operative effectiveness of osseodensification burs relative to conventional drilling. With comprehensive statistical backing (T-tests, ANOVA, interaction effects), results consistently favored osseodensification across all metrics: OHI, Plaque, Calculus, Pain, and Thermal Index. Significant main effects and interaction terms demonstrate that age, gender, and education level modulate surgical outcomes, highlighting the superiority of osseodensification, especially in younger individuals. Figures and tables validate each hypothesis and correlate well with existing literature affirming improved implant stability, reduced trauma, and better hygiene maintenance. The findings align with numerous peer-reviewed studies (e.g., Antal & Novak, 2025; Shanmugam et al., 2024) and expand upon the known benefits of osseodensification, particularly in reducing thermal injury and promoting healing. Any observed variance with other surgical innovations such as Piezosurgery was marginal and context-specific. Thus, this investigation substantiates that osseodensification is not only minimally invasive but significantly enhances post-surgical outcomes, affirming both the study's objectives and hypotheses.

DECLARATIONS

Funding

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Conflict of Interest

The authors declare no conflict of interest.

Ethical Approval

This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Institutional Medical Ethics Committee.

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none

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