RESEARCH PAPER

Assessment Of Impact Of Smoking On Early Healing Outcomes After Immediate Implant Placement, A Case Control Study.

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ABSTRACT

Background:Immediate Implant Placement (Iip), Where Implants Are Inserted Directly Into Extraction Sockets, Offers Reduced Treatment Time, Enhances Aesthetics And Patient Related Outcomes. Smoking Is Believed To Negatively Affect Wound Healing And Osseointegration, Making Immediate Implants A Less Preferable Therapy In This Cohort With Contradicting Evidence Of Literature. This Study Aimed To Evaluate And Compare Secondary Stability And Early Healing Outcomes Of Iip Among Smokers And Non-Smokers.

Materials And Methods:Twenty-Two Edentulous Sites Were Categorized Into 2 Groups: Group 1 (Non- Smokers, N=11) And Group 2 (Smokers, N=11). Implants Were Placed Using A Flapless Technique. Resonance Frequency Analysis (Rfa) Assessed Implant Stability At Baseline And At 4, 8, 12, And 16 Weeks. Marginal Bone Loss (Mbl), Buccal Bone Thickness, Pink Esthetic Score (Pes), Wound Healing Index (Whi), Visual Analogue Scale For Pain (Vas-P) Were Assessed.

Results: Group 1 Showed Significantly Higher Implant Stability (Isq: 77.00 ± 1.12) Than Group 2 (72.09 ± 1.13). Group 2 Demonstrated Greater Mbl (Mesial: 0.40 Mm, Distal: 0.38 Mm) Versus Group 1 (Mesial: 0.18 Mm, Distal: 0.11 Mm). Pes And Whi Were Higher In Non-Smokers (Pes: 10.50 Vs. 9.27; Whi: 5.00 Vs. 4.72). Pain Scores Were Lower In Group 1 (2.50 Vs. 3.36).

Conclusion: Based On The Study Findings, It Can Be Ascertained That Secondary Stability Substantially Increased In Both Groups. However, Smokers Experienced A Notable Dip In Stability At 8 Weeks, With Greater Bone Loss, Pain, And Compromised Healing Outcomes. Nevertheless, Efforts On Smoking Cessation Should Be Encouraged Prior To Implant Placement And Caution On Prosthetic Loading May Further Improve Implant Success Among Smokers.

Categories: Dentistry...

Keywords: immediate implants, implant stability, osseointegration, pink esthetics, smoking, wound healing..

How to cite this article: Elango P, Parthasarathy H, Ramachandran L, Tadepalli A, Cholan P, Kamalakannan H. Assessment of Impact of Smoking on Early Healing Outcomes After Immediate Implant Placement, A Case Control Study. Int J Drug Deliv Technol. 2026;16(24s): 1000-1008. DOI: 10.25258/ijddt.16.24s.120

Source of support: Nil.

Conflict of interest: Nil.

INTRODUCTION

Immediate implant placement (IIP) is the placement of a dental implant directly into a fresh extraction socket-has become increasingly popular because of its clinical and patient-centered advantages. These include reduced treatment time, fewer surgical interventions, better alveolar ridge anatomy preservation, improved soft tissue aesthetics [1]. However, the success of IIP may be compromised by various risk factors, most notably smoking. Smoking exerts detrimental effects on both hard and soft oral tissues by impairing angiogenesis, reducing immune responses, and disrupting cellular repair mechanisms, which are essential during the early healing phase of implant osseointegration [2]. Numerous studies have firmly established that Cigarette smoking substantially increases implant failure rates compared to non-smokers, greater marginal bone loss, and a higher prevalence of periimplant diseases [3].Clinically, IIP offers benefits such as maintaining alveolar bone contours and minimizing surgical trauma, thus enhancing patient satisfaction [4].Favourable soft tissue outcomes, including emergence profile and gingival contour, are more easily achieved with immediate placement. However, these benefits can be significantly diminished in smokers. A case series by Wychowański et al. reported that, although IIP can provide outcomes comparable to delayed protocols, smoking status remains a critical factor [5]. Implant stability is often assessed with Resonance Frequency Analysis (RFA), provides

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insights into the osseointegration process. The Implant Stability Quotient is a non-invasive, quantifiable measure of both primary mechanical anchorage and secondary biological integration. In a clinical trial, Wychowański et al. found significantly lower ISQ values in smokers compared to non-smokers, indicating impaired peri-implant healing in the former group. Similarly, Chatzopoulos and Wolff observed a marked decline in ISQ values around the eighth week in smokers, suggesting delayed or hindered osseointegration [6]. Soft tissue healing is also adversely affected by smoking [7]. These differences are primarily due to the vasoconstrictive effects of nicotine, which impairs blood supply and delays healing. Nicotine-induced hypoxia compromises the regenerative potential of gingival tissues, raising the risk of complications [8]. Additionally, smoking alters the oral microbiome by reducing microbial diversity and promoting pathogenic species, which further impedes soft tissue repair [9]. Pain perception and postoperative healing are also negatively affected by smoking. While some studies suggest that smokers do not experience significantly higher pain levels during initial healing phases [10], impaired healing mechanisms likely contribute to prolonged discomfort and increased sensitivity. The combination of reduced vascularity and delayed epithelialization results in greater inflammation and postoperative morbidity. Moreover, peri-implant diseases are more common in smokers, often requiring additional interventions and prolonged pain management strategies [8]. Changes in the salivary microbiome may further exaggerate inflammatory responses and discomfort [9]. Morishita et al. found that both conventional cigarette uses, and heated tobacco products impair wound healing, showing that even alternative nicotine sources can compromise implant outcomes [11]. Peri-implant soft tissue outcomes are commonly evaluated using the Pink Esthetic Score (PES), which consistently reveals lower scores among smokers. This is attributed to delayed healing, gingival recession, and discoloration [12]. These aesthetic shortcomings can significantly affect patient satisfaction and the overall success of the treatment. Recent systematic reviews further reinforce the negative impact of smoking on dental implant success. Stiller et al., [13] highlighted a strong relationship between smoking and increased implant failure rates, noting that higher daily cigarette consumption exacerbates this risk. Chrcanovic et al. reported that smokers have a 140.2% higher risk of implant failure and greater marginal bone loss compared to non-smokers [14]. Khouly et al. concluded that smoking significantly greater the risk of early implant failure, particularly during the initial healing phase [15]. Despite abundant research, evidence remains conflicting regarding the predictability of IIP in smokers. Some studies show comparable success rates when meticulous protocols are followed, while others report greater failure rates and complications in smokers. This discrepancy highlights the need for further investigation into the multifactorial effects of smoking on IIP. Therefore, this study sought to evaluate and compare secondary implant stability, changes in marginal bone, soft tissue aesthetics, and patient-reported outcomes following immediate implant placement between smokers and non-smokers.

MATERIALS AND METHODS

The present observational case-control study was performed at the Department of Periodontics, SRM Dental College, Ramapuram, Chennai-89, India, over the period from September 2023 to October 2024. Ethical clearance was secured from the Institutional Review Board and Scientific Committee (SRMDC/IRB/2022/MDS/NO.508), with prospective registration in the Clinical Trials Registry of India (CTRI/2023/10/058645). Participants requiring implant therapy for missing teeth in the maxillary or mandibular arches were recruited and categorized based on smoking status. Sample size determination was performed using G*Power software, referencing prior literature, resulting in a total of 22 participants divided equally into two groups (n = 11 per group). Group 1 (G1) - immediate implant placement in nonsmokers (control), and Group 2 (G2) - immediate implant placement in smokers (test). Inclusion criteria for immediate implant placement included male patients aged between 25-60 years undergoing implant insertion into fresh extraction sockets on the day of tooth removal. Group 1 included non-smokers, whereas Group 2 included current smokers with a 5-10 pack-year history. Exclusion criteria encompassed long-term bisphosphonate use (>3 years), known allergies to medications or materials used in the study, prior head and neck radiotherapy, chemotherapy within the last 12 months, significant psychological disorders, and unwillingness to provide informed consent. All Participants were given detailed information concerning the treatment methods, anticipated benefits, and risks involved before they provided written informed consent. All clinical and radiographic evaluations were performed by a single calibrated examiner, with intraexaminer reliability established prior to commencement.

The primary parameters assessed included implant stability using resonance frequency analysis, crestal bone level and thickness, pain intensity via the Visual Analog Scale (VAS-P), Pink Esthetic Score (PES) and Wound Healing Index (WHI). All surgical procedures were standardized and began with general and haematological examinations, followed by Phase I therapy. Instruction in oral hygiene, non-surgical periodontal therapy, and restorative corrections, and caries management. Preoperative imaging included CBCT scans. Local anesthesia was administered before implant osteotomy was performed under copious saline irrigation. Conventional rough surface RBM implants were inserted, and primary stability was achieved, healing cap was placed. Initial implant stability was assessed using RFA and the position of implant were confirmed with Radiovisiography (RVG).

Postoperative care included instructions on cold compress application, meticulous oral hygiene, 0.12% chlorhexidine mouthrinse, and a regimen of oral antibiotics (Amoxicillin 625 mg + Potassium Clavulanate + Metronidazole 400 mg) along with analgesics (Aceclofenac 100 mg + Paracetamol 500 mg). Follow-up visits were scheduled at 1,2, 4, 8, 12, and 16 weeks. ISQ measurements and soft tissue evaluations were recorded at specified time intervals, CBCT imaging was conducted at 16-week follow-up

RESULTS:

This study assessed the outcomes of immediate implant placement among non-smokers (Group 1) and smokers (Group 2), with 11 patients in each group. A total of 22 implants were placed immediately into fresh extraction sockets. A total of 22 implants were evaluated for secondary stability, crestal bone levels and thickness, pain scores, wound healing, and soft tissue esthetic outcomes over multiple follow-up intervals. STATISTICAL ANALYSIS Using IBM SPSS Statistics for Windows version 20.0 (IBM Corp., 2011), both descriptive and inferential statistics were calculated. One-way ANOVA assessed differences between groups for Age, ISQ, Crestal bone level and thickness, VAS-P, Wound Healing Index, and soft tissue evaluations. Changes within groups were analysed by Repeated Measures ANOVA with Tukey's HSD test. Data were graphically presented via bar charts. Statistical significance was defined as $p < 0.05$.None of the data is represented as percentage. Secondary implant stability measured was consistently higher in non-smokers across all time intervals. (GRAPH 1) Group 1 showed a progressive increase from ISQ of 71.66±1.61 at baseline to 77.00±1.12 at 16 weeks. In contrast, Group 2 recorded lower values throughout, beginning at 68.09±1.13 and reaching only 72.09±1.13 at the 16-week. The intragroup pairwise comparison of ISQ values in Group1 across all study timelines, using repeated measures ANOVA, showed statistically significant differences when compared between all timelines ($p < 0.05$). (TABLE 1)

TABLE 1: TABLE 1 DEPICTS ISQ VALUES OF STUDY GROUPS AT VARIOUS TIME INTERVALS

*Denote the significant value.

One-way ANOVA statistical test was employed to assess the intergroup differences.

Intragroup were analysed by Repeated Measures ANOVA with Tukey's HSD test.

F value determines the Test Statistics (F-statistics)

Statistical significance was defined as $p<0.05$

GROUPS	0 DAY (MEAN±SD)	4 WEEKS (MEAN± SD)	8 WEEKS (MEAN ±SD)	12 WEEKS (MEAN±SD)	16 WEEKS (MEAN± SD)	P VALUE
IMMEDIATE NON-SMOKER (GROUP 1)	71.66±1.61	73.33±1.37	70.66±1.61	75.08±1.08	77.00±1.12	
IMMEDIATE SMOKER (GROUP 2)	68.09±1.13	70.09±1.13	66.45±1.50	71.09±1.13	72.09±1.13	<0.001*
F VALUE	106.559	133.825	77.821	160.585	185.796	

Radiographic evaluations revealed greater preservation of crestal bone in non-smokers. Group 1 demonstrated mesial and distal crestal bone loss of 0.1892 mm and 0.1133 mm, respectively, whereas smokers (Group 2) experienced more pronounced resorption-0.4027 mm mesially and 0.3809 mm distally. Similarly, buccal bone thickness showed less reduction in Group 1 (0.5545 mm) compared to Group 2 (0.8045 mm). At the 16-week follow-up, mesial and distal crestal bone levels were significantly lower in Group 1 (Non-smokers) compared to Group 2 (Smokers). Mesial bone loss was 0.18 ± 0.09 mm in Group 1 vs. 0.40 ± 0.08 mm in Group 2. Distal bone loss was 0.11 ± 0.044 mm in Group 1 vs. 0.38 ± 0.080 mm in Group 2. Group 1 demonstrated significantly lower buccal bone thickness (1.68 ± 0.04 mm) compared to Group 2 (1.86 ± 0.11 mm). This difference was statistically significant ($p < 0.001$). The intergroup comparison across all the timelines for crestal bone level evident there is a statistically significant difference in mesial and distal values among the groups and the pairwise comparison among groups for mesial crestal bone levels, revealing significant differences between the smoker and non-smoker groups. However, the differences between the smoker group and the non-smoker group were not statistically significant. Thus, at 16 weeks, the nonsmoker group exhibited significantly less crestal bone loss compared to the smoker group, both mesially and distally. (TABLE 2)

Table 2 Shows The Crestal Bone Level And Crestal/Buccal Bone Thickness At 16 Th Week Follow-Up

GROUPS	MESIAL CRESTAL BONE LEVEL (MEAN ± SD)	DISTAL CRESTAL BONE LEVEL (MEAN ± SD)	F VALUE	BUCCAL BONE THICKNESS (MEAN ± SD)	F VALUE	P VALUE
IMMEDIATE NON-SMOKER (GROUP 1)	0.18 ± 0.09	0.11 ± 0.044	27.890	1.68 ± 0.04	2221.750	<0.001*
IMMEDIATE SMOKER (GROUP 2)	0.40 ± 0.08	0.38 ± 0.080	41.078	1.86 ± 0.11	1648.102	<0.001*

*Denote the significant value.

One-way ANOVA statistical test was employed to assess the intergroup differences.

Intragroup were analysed by Repeated Measures ANOVA with Tukey's HSD test.

F value determines the Test Statistics (F-statistics)

Statistical significance was defined as $p<0.05$

Soft tissue aesthetics evaluated using the Pink Esthetic Score (PES) which steadily improved in both groups throughout the study period. Group 1 (Non-smokers) improved from 9.00 ± 0.73 at baseline to 10.50 ± 0.52 at 16 weeks. Group 2 (Smokers) improved from 7.54 ± 0.52 to 9.27 ± 0.46. Both intragroup and intergroup comparisons demonstrated statistically significant differences ($p < 0.001$), with Group 1 maintaining superior esthetic scores at all time points. Smokers showed lower baseline and final

PES values, ranging from 7.54 to 9.27, indicating comparatively reduced soft tissue regeneration and colour harmony. Wound healing was assessed from 4 to 16 weeks. Group 1 (non-smokers) showed continuous improvement, achieving complete healing by 16 weeks (5.00 ± 0.00). In contrast, Group 2 (smokers) also exhibited progressive healing but had significantly lower wound healing scores at each point. At 16 weeks, smokers recorded 4.72 ± 0.46, indicating delayed healing compared to non-smokers ($p < 0.001$). Wound healing progressed more rapidly in non-smokers, who demonstrated complete healing by 16 weeks. Wound healing outcomes were also better in non-smokers, who achieved complete soft tissue closure by 16 weeks, whereas smokers exhibited delayed epithelialization and lower wound healing index scores during early time points. (TABLE 3) Postoperative pain was evaluated using the

Table 3 Shows The Intra Group Assessment Of Soft Tissue Parameters In The Groups

PARAMETERS	*GROUP*	*TIMELINE*	*MEAN*	*STD. DEVIATION*	*F VALUE*	*P VALUE*
PINK ESTHETIC SCORE	IMMEDIATE NON-SMOKER	4 WEEKS	9.5	0.52	40.616	*<0.001*
		8 WEEKS	9.66	0.49	51.590	
		12 WEEKS	9.91	0.66	55.992	
		16 WEEKS	10.50	0.52	67.730	
	IMMEDIATE SMOKER	4 WEEKS	8.27	0.64	40.616	
		8 WEEKS	8.54	0.52	51.590	
		12 WEEKS	8.81	0.40	55.992	
		16 WEEKS	9.27	0.46	67.730	
WOUND HEALING INDEX	IMMEDIATE NON-SMOKER	4 WEEKS	3.75	0.45	11.162	*<0.001*
		8 WEEKS	4.50	0.52	14.017	
		12 WEEKS	4.75	0.45	4.369	
		16 WEEKS	5.00	0.00	2.739	
	IMMEDIATE SMOKER	4 WEEKS	3.45	0.52	11.162	
		8 WEEKS	3.72	0.46	14.017	
		12 WEEKS	4.45	0.52	4.369	
		16 WEEKS	*4.72*	*0.46*	*2.739*	

*Denote the significant value.

One-way ANOVA statistical test was employed to assess the intergroup differences.

Intragroup were analysed by Repeated Measures ANOVA with Tukey's HSD test.

F value determines the Test Statistics (F-statistics)

Statistical significance was defined as $p<0.05$.

Visual Analog Scale for Pain (VAS-P). Group 1 reported significantly lower pain scores, from 6.16 ± 0.71 at day 0 to 2.50 ± 0.52 at 2 weeks. Group 2 had higher scores, descending from 7.54 ± 0.52 at baseline to 3.36 ± 0.50 at 2 weeks. Statistically significant differences were observed between groups at all intervals ($p < 0.001$), with non-smokers exhibiting faster pain resolution.

RESULTS:

This study assessed the outcomes of immediate implant placement among non-smokers (Group 1) and smokers (Group 2), with 11 patients in each group. A total of 22 implants were placed immediately into fresh extraction sockets. A total of 22 implants were evaluated for secondary stability, crestal bone levels and thickness, pain scores, wound healing, and soft tissue esthetic outcomes over multiple follow-up intervals. STATISTICAL ANALYSIS Using IBM SPSS Statistics for Windows version 20.0 (IBM Corp., 2011), both descriptive and inferential statistics were calculated. One-way ANOVA assessed differences between groups for Age, ISQ, Crestal bone level and thickness, VAS-P, Wound Healing Index, and soft tissue evaluations. Changes within groups were analysed by Repeated Measures ANOVA with Tukey's HSD test. Data were graphically presented via bar charts. Statistical significance was defined as $p < 0.05$.None of the data is represented as percentage. Secondary implant stability measured was consistently higher in non-smokers across all time intervals. (GRAPH 1) Group 1 showed a progressive increase from ISQ of 71.66±1.61 at baseline to 77.00±1.12 at 16 weeks. In contrast, Group 2 recorded lower values throughout, beginning at 68.09±1.13 and reaching only 72.09±1.13 at the 16-week. The intragroup pairwise comparison of ISQ values in Group1 across all study timelines, using repeated measures ANOVA, showed statistically significant differences when compared between all timelines ($p < 0.05$). (TABLE 1) Radiographic evaluations revealed greater preservation of crestal bone in non-smokers. Group 1 demonstrated mesial and distal crestal bone loss of 0.1892 mm and 0.1133 mm, respectively, whereas smokers (Group 2) experienced more pronounced resorption-0.4027 mm mesially and 0.3809 mm distally. Similarly, buccal bone thickness showed less reduction in Group 1 (0.5545 mm) compared to Group 2 (0.8045 mm). At the 16-week follow-up, mesial and distal crestal bone levels were significantly lower in Group 1 (Non-smokers) compared to Group 2 (Smokers). Mesial bone loss was 0.18 ± 0.09 mm in Group 1 vs. 0.40 ± 0.08 mm in Group 2. Distal bone loss was 0.11 ± 0.044 mm in Group 1 vs. 0.38 ± 0.080 mm in Group 2. Group 1 demonstrated significantly lower buccal bone thickness (1.68 ± 0.04 mm) compared to Group 2 (1.86 ± 0.11 mm). This difference was statistically significant ($p < 0.001$). The intergroup comparison across all the timelines for crestal bone level evident there is a statistically significant difference in mesial and distal values among the groups and the pairwise comparison among groups for mesial crestal bone levels, revealing significant differences between the smoker and non-smoker groups. However, the differences between the smoker group and the non-smoker group were not statistically significant. Thus, at 16 weeks, the nonsmoker group exhibited significantly less crestal bone loss compared to the smoker group, both mesially and distally. (TABLE 2) Soft tissue aesthetics evaluated using the Pink Esthetic Score (PES) which steadily improved in both groups throughout the study period. Group 1 (Non-smokers) improved from 9.00 ± 0.73 at baseline to 10.50 ± 0.52 at 16 weeks. Group 2 (Smokers) improved from 7.54 ± 0.52 to 9.27 ± 0.46. Both intragroup and intergroup comparisons demonstrated statistically significant differences ($p < 0.001$), with Group 1 maintaining superior esthetic scores at all time points. Smokers showed lower baseline and final PES values, ranging from 7.54 to 9.27, indicating comparatively reduced soft tissue regeneration

and colour harmony. Wound healing was assessed from 4 to 16 weeks. Group 1 (non-smokers) showed continuous improvement, achieving complete healing by 16 weeks (5.00 ± 0.00). In contrast, Group 2 (smokers) also exhibited progressive healing but had significantly lower wound healing scores at each point. At 16 weeks, smokers recorded 4.72 ± 0.46, indicating delayed healing compared to non-smokers ($p < 0.001$). Wound healing progressed more rapidly in non-smokers, who demonstrated complete healing by 16 weeks. Wound healing outcomes were also better in non-smokers, who achieved complete soft tissue closure by 16 weeks, whereas smokers exhibited delayed epithelialization and lower wound healing index scores during early time points. (TABLE 3) Postoperative pain was evaluated using the Visual Analog Scale for Pain (VAS-P). Group 1 reported significantly lower pain scores, from 6.16 ± 0.71 at day 0 to 2.50 ± 0.52 at 2 weeks. Group 2 had higher scores, descending from 7.54 ± 0.52 at baseline to 3.36 ± 0.50 at 2 weeks. Statistically significant differences were observed between groups at all intervals ($p < 0.001$), with non-smokers exhibiting faster pain resolution

Pain levels were higher in smokers, especially during the first two weeks postoperatively. Group 2 consistently reported greater discomfort than Group 1. Overall, the results demonstrated that immediate implant placement in non-smokers led to superior outcomes in terms of implant stability, crestal bone preservation, aesthetic integration, pain reduction, and wound healing compared to smokers. (GRAPH 2)

DISCUSSION:

The present study investigated the early healing outcomes of immediate implant placement in smokers and non-smokers, revealing consistently superior outcomes in the non-smoking cohort across multiple parameters, including implant stability, crestal bone preservation, soft tissue aesthetics, and post-operative pain. Implant Stability According to Chen and Buser [1], IIP helps maintain soft tissue contours and minimizes post-extraction ridge resorption, improving esthetic outcomes when appropriate case selection is made. However, achieving successful outcomes requires precise control over surgical variables and is heavily dependent on primary stability and absence of local pathology. This research focused on assessing and comparing the outcomes of IIP in non-smokers (Group 1) and smokers (Group 2). Resonance frequency analysis was employed to measure implant stability using the Implant Stability Quotient (ISQ) demonstrated significantly higher and more consistent values in nonsmokers. This group showed an increase from 71.66±1.61 at baseline to 77.00±1.12 at 16 weeks. In contrast, smokers exhibited lower and slower ISQ progression (68.09±1.13 to 72.09±1.13). (GRAPH 1)The Implant Stability Quotient (ISQ) values in this study were significantly higher in non-smokers at all time points, consistent with the results of studies by Shibli et al., [16] and Rodrigo et al., [17] which reported impaired osseointegration and delayed implant stability in smokers. The present study recorded a mean RFA score of approximately 71.09±1.13 ISQ in smokers after 12 weeks, comparable to the results documented by Gangwar et al., [8] The progressive increase in ISQ observed in both groups reflects ongoing healing and integration.

However, the slower progression in smokers could be attributed to the compromised vascularization and inflammatory responses. Wychowański et al., [4,5] reinforced that smoking has a substantial adverse effect on the immediate stability of dental implants in the maxilla, thereby suggested that both patients and clinicians should recognize the increased risks associated with smoking and prioritize smoking cessation to improve implant outcomes. Radiographic outcomes demonstrated greater crestal bone loss in smokers, which corroborates with findings by Lindquist et al., [18] who observed that Marginal bone loss was significantly greater in smokers than nonsmokers and further re-emphasised that the amount of bone loss correlates with the number of cigarette consumption. Balatsouka et al., [19] noted that smoking exacerbates marginal bone resorption, likely due to impaired angiogenesis and osteoblastic activity. We observed the notably lower mesial and distal bone loss in non-smokers (0.1892 mm and 0.1133 mm, respectively) in our study reinforcing the impact of smoking ion marginal bone loss. It has been demonstrated that Smokers typically exhibit greater MBL due to impaired bone remodelling and heightened inflammatory responses. Wychowański also highlighted increased buccal bone resorption in smokers, which adversely affects aesthetic outcomes. Since the buccal bone plate is often thin and susceptible to resorption post-extraction, preserving it is crucial-particularly in the aesthetic zone. Smoking accelerates this resorption, often leading to gingival recession and soft tissue collapse. Our findings are in agreement with the meta-analysis by Wychowański et al., [5] which confirmed significantly lower ISQ values and higher bone loss in smokers undergoing IIP. Reduction in buccal bone thickness was also more pronounced in smokers, mirroring findings from studies by Barone et al., [20] which emphasize the importance of buccal bone integrity in aesthetic outcomes. The greater loss observed in smokers (0.8045 mm vs. 0.5545 mm in non-smokers) supports the notion that smoking may impair the maintenance of labial bone, potentially compromising long-term implant esthetics. The Pink Esthetic Score (PES) outcomes in our study showed better soft tissue aesthetics in non-smokers, echoing the observations made by Fürhauser et al., [21] and Romeo et al., [22] who found that smoking negatively affects soft tissue healing and color integration. The progressive increase in PES from baseline to end of the study among non-smokers suggests a healthier peri-implant mucosal environment, crucial for achieving natural-looking outcomes in anterior implant zones. Pain assessments revealed higher VAS scores in smokers throughout the early healing phase, a pattern also noted by Bain and Moy [23]. This may be attributed to smoking-induced vasoconstriction and increased inflammatory mediators, which can intensify post-operative discomfort. Our findings support the recommendation to discourage smoking, especially during the peri-operative period, to enhance patient comfort and recovery. Pain score was observed to be

nil at week 4 and week 12 in both the groups While the results of this study are consistent with existing literature, the sample size was relatively small (n=11 per group), which may limit generalizability. Future studies with larger cohorts and longer follow-up periods are warranted to further elucidate the long-term effect of smoking on implant outcomes. Moreover, stratifying smokers by the number of cigarettes per day or duration of smoking history could provide more nuanced insights into dose-dependent effects. Interestingly, the study also noted no significant differences in long-term survival rates between protocols, suggesting that risk mitigation strategies can improve outcomes for smokers. Romanos et al., [24] also reported high long-term success rates in smokers when platform-switched implants were used in tandem with protocols that avoided repeated abutment disconnections. These results emphasize that minimizing micromovements and maintaining a stable peri-implant seal are crucial for preventing inflammation especially in smokers.

The literature consistently shows that smoking detrimental impacts dental implant outcomes, with smokers experiencing delayed healing and inferior clinical responses compared to non-smokers. For example, implant failure rates are reported to be around 10% in smokers compared to 4% in non-smokers [4]. The risk further escalations among individuals smoking 20 cigarettes or more per day. Smoking is also linked with reduced bone regeneration, greater probing depths, and poorer clinical attachment levels. Effectiveness of peri-implantitis treatment is significantly reduced in smokers, who show a 50-75% reduction in clinical improvement. Nevertheless, some studies indicate that smoking cessation can lead to improved periodontal health and better implant outcomes [2, 25]. Moreover, smoking aggravates peri-implantitis, leading to elevated plaque levels and increased bleeding on probing [12]. Crestal bone loss (MBL) was also more significant in the smoking cohort. Karni et al., and Kumar et al., [26, 27] observed similar trends, where immediate placement resulted in higher MBL compared to delayed protocols. Our study showed that MBL in non-smokers was 0.1892 mm (mesial) and 0.1133 mm (distal), while in smokers it reached 0.4027 mm and 0.3809 mm, respectively. In evaluating buccal bone thickness, we found greater loss in smokers (0.8045 mm) compared to non-smokers (0.5545 mm). This agrees with Chrcanovic et al., [14] who found that smokers had significantly increased marginal and buccal bone resorption compared to non-smokers, primarily due to compromised healing and bone metabolism. Esthetic integration, assessed by the Pink Esthetic Score (PES), improved in both groups but remained consistently higher in non-smokers. The PES increased from 9.00 to 10.50 in non-smokers and from 7.54 to 9.27 in smokers by 16 weeks. Buser et al., [28] emphasized that intact soft tissue contours around implants are critical for esthetic success, and any factor impairing vascularity such as smoking-can negatively influence these outcomes. Riachi et al., [29] in their systematic review, also confirmed that delayed placement tends to yield higher esthetic outcomes, especially in patients with favourable tissue biotypes and low-risk profiles. Pain perception assessed by the Visual Analog Scale (VAS) revealed consistently higher scores in smokers during early healing phases. These findings align with those of Wang et al., [10] who reported higher postoperative discomfort in smokers due to inflammation and delayed healing.Bain & Moy [23] have both noted that smoking delays wound closure by impairing angiogenesis and fibroblast proliferation. Papi et al., [30] also observed delayed healing in IIP cases, particularly when combined with negative patient-related factors like smoking or poor plaque control. Wound healing outcomes were also better in non-smokers, who achieved complete soft tissue closure by 16 weeks, whereas smokers exhibited delayed epithelialization and lower wound healing index scores during early time points. Overall, the results demonstrated that immediate implant placement in non-smokers led to superior outcomes in terms of implant stability, crestal bone preservation, aesthetic integration, pain reduction, and wound healing compared to smokers. This investigation is subject to several limitations that should be taken into account when evaluating its results. The limited sample size may compromise statistical strength and the broader applicability of the conclusions, while a brief follow-up period provides only partial insight into the longevity of implant success and the stability of crestal bone. Furthermore, the lack of data regarding crestal bone loss after loading restricts the full understanding of how functional forces impact bone dynamics. The study's focus on predominantly male participants, in line with existing smoking trends, could cause selection bias and reduce the relevance of the findings for female populations. For more robust evidence, future research should aim for larger and more varied participant groups, increased follow-up intervals, and detailed assessment of bone changes after functional loading. Conclusions Collectively, this research suggest that while IIP remains a predictable and successful treatment modality in non-smokers, its performance is notably compromised in smokers. The cumulative evidence underscores the need for stringent case selection and risk assessment before performing IIP in smokers. Smoking cessation counselling, careful surgical technique, and modified loading protocols are essential strategies to mitigate risk and enhance clinical outcomes..

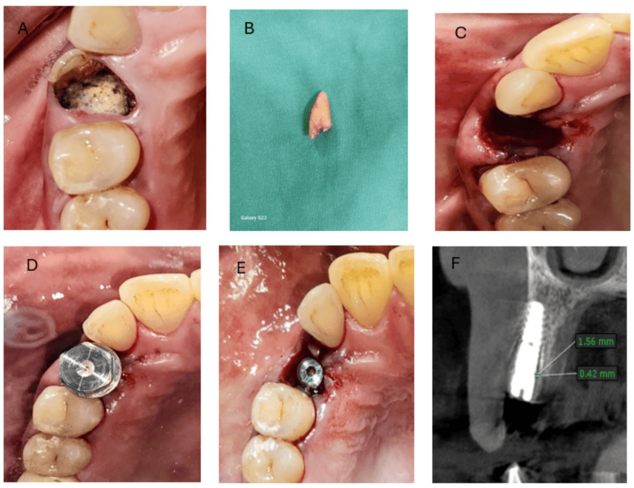

FIGURE 1: GROUP I: IMMEDIATE NON-SMOKER

FIGURE 1A: PRE OP
FIGURE 1B: EXTRACTION OF 13
FIGURE 1C: POST EXTRACTION
FIGURE 1D: IMMEDIATE IMPLANT PLACEMENT
FIGURE 1E: HEALING CAP PLACEMENT AND POST OP
FIGURE 1F: CBCT EVALUATION AFTER 4 MONTHS

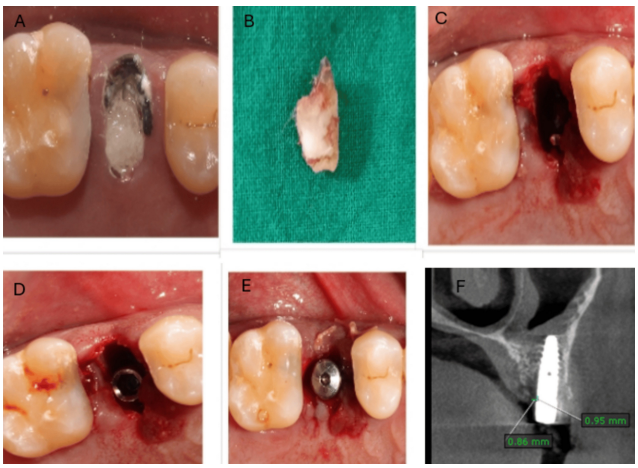

FIGURE 2: GROUP 2: IMMEDIATE SMOKER

FIGURE 2A: PRE OP
FIGURE 2B: EXTRACTION OF 25
FIGURE 2C: POST EXTRACTION
FIGURE 2D: IMMEDIATE IMPLANT PLACEMENT IN 25
FIGURE 2E: HEALING CAP PLACEMENT AND POST – OP
FIGURE 2F: CBCT EVALUATION AFTER 4 MONTHS

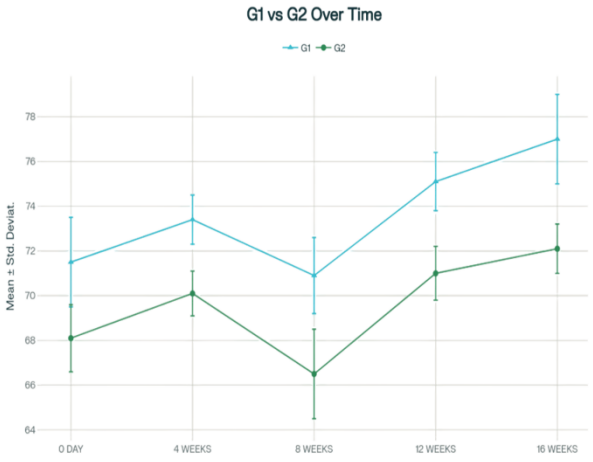

FIGURE 3:
GRAPH 1: SHOWS INTRAGROUP VARIATIONS IN ISQ VALUES FOR GROUP 1 AND GROUP 2 ACROSS VARIOUS TIMELINES
G1: IMMEDIATE NON-SMOKER (GROUP 1)
G2: IMMEDIATE SMOKER (GROUP2)

Line chart showing G1 vs G2 over time with error bars for each group at each time point. The X-axis represents "Time" (0 DAY, 4 WEEKS, 8 WEEKS, 12 WEEKS, 16 WEEKS), and the Y-axis shows "Mean ± Std. Deviation." G1 is represented by a blue line with triangle markers, and G2 is represented by a green line with circle markers.
Line chart showing G1 vs G2 over time with error bars

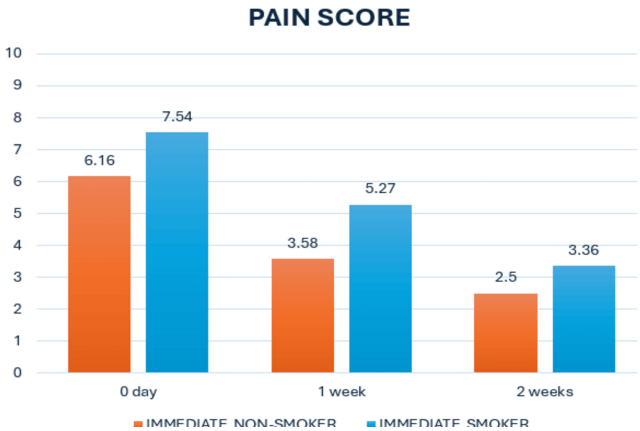

FIGURE 4:
GRAPH 2 ILLUSTRATE THE MEAN DESCRIPTIVE STATISTICS OF INTRAGROUP PARAMETERS IN ALL THE GROUPS AT VARIOUS TIME POINTS FOR VAS-P

REFERENCE

1. Chen S.T., Buser D. Clinical and esthetic outcomes of implants placed in postextraction sites. Int. J. Oral Maxillofac. Implant. 2009;24((Suppl. 24)):186-217.
2. Chrcanovic, B. R., Albrektsson, T., & Wennerberg, A. (2015: Smoking and dental implants: A systematic review and meta-analysis. Journal of Dentistry. 43:487-498.
3. Kan, J. Y., Rungcharassaeng, K., & Lozada, J. L. (2007: Immediate placement and provisionalization of maxillary anterior single implants: 1-year prospective study. International Journal of Oral & Maxillofacial Implants. 22:753-760.
4. Wychowański, P., Wychowańska, D., & Wiśniewska-Pałyska, A. (2020: The Effects of Smoking Cigarettes on Immediate Dental Implant Stability—A Prospective Case Series Study. Medical Science Monitor. 26:922907. 10.3390/app11010027
5. Wychowański P, Bołtryk M, Krukowska J: Evaluation of primary and secondary stability of dental implants in smokers and non-smokers using resonance frequency analysis (RFA). J Clin Med. 2022, 11:682.
6. Chatzopoulos, G. S., & Wolff, L. F. (2022: Survival Rates and Factors Affecting the Outcome Following Immediate and Delayed Implant Placement: A Retrospective Study. Journal of Oral Implantology. 48:31-38. 10.3390/jcm11154598
7. Raes, S., Rocci, A., Raes, F.,(2015: A prospective cohort study on the impact of smoking on soft tissue alterations around single implants. Clinical Oral Implants Research. 26:1086-1090.

8. Gangwar M, Verma P, Verma KG, Khosa R: Gangwar S, Pal US, Singh S, Singh RK, Singh V, Kumar L. Immediately placed dental implants in smokers with plasma rich in growth factor versus without plasma rich in growth factor: A comparison. Natl J Maxillofac Surg. 2018 Jan-Jun;9(1):39-47. doi: 10.4103/njms.NJMS_74_17. PMID: 29937657; PMCID: PMC5996649.. J Indian Soc Periodontol. 2018, 22:32- 37. 10.4103/njms.NJMS_74_17

9. Duan X, Wu T, Xu X, : Smoking may lead to marginal bone loss around non-submerged implants during bone healing by altering salivary microbiome: A prospective study. J Periodontol. 2017, 88:1297-1308. 10.1902/jop.2017.160808

10. Wang X, Zhang Y, Wu Y, Bai X, Lin H: Evaluation of pain perception after dental implant surgery: A clinical study. Pain Res Manag. 2017, 2017:3430609. 10.1155/2017/3430609

11. Morishita, Y., Hasegawa, S., Koie, S. (2023: Effects of heated tobacco products and conventional cigarettes on dental implant wound healing: experimental research. Annals of Medicine and Surgery. 85:1366-1370.

12. Madi, M., Smith, S., Alshehri, S.(2023: Influence of Smoking on Periodontal and Implant Therapy: A Narrative Review. International Journal of Environmental Research and Public Health, 20, 5368.

13. Stiller S, Pourhassan B, Al-Nawas B: Effect of smoking on dental implants: A systematic review and meta-analysis. Clinical Oral Implants Research. 2024, 35:202-214. 10.1111/clr.13948

14. Chrcanovic BR, Albrektsson T, Wennerberg A. Smoking and dental implants: Updated systematic review and meta-analysis on implant survival and marginal bone loss. Journal of Dentistry. 2022, 122:104119. 10.1016/j.jdent.2022.104119

15. Khouly I, Javed F, Romanos GE: Impact of smoking on early dental implant failure: A systematic review and meta-analysis. Clinical Oral Implants Research. 2024, 35:78-86. 10.1111/clr.13905

16. Shibli JA, Froum S, : Implant surface influences biofilm-induced peri-implant mucositis in humans . J Periodontol. 2010, 81:528-535. 10.1902/jop.2010.090545

17. Rodrigo D, Aracil L, Martin C, Sanz M: Diagnosis and treatment of peri-implant diseases. Open Dent J. 2014, 8:190-198. 10.2174/1874210601408010190

18. Lindquist LW, Carlsson GE, Jemt T: Association between marginal bone loss around osseointegrated mandibular implants and smoking habits: a 10-year follow-up study. Journal of Dental Research. 1997, 76:1667-1674. 10.1177/00220345970760100801

19. Balatsouka D, Gotfredsen K, Lindh CH, Berglundh T: Marginal bone level changes at dental implants coated with type I collagen: A histometric study in the dog. Clinical Oral Implants Research. 2005, 16:645-652.

20. Barone A, Toti P, Marconcini S, Derchi G, Saverio M, Covani U: Esthetic outcome of implants placed in fresh extraction sockets by clinicians with or without experience: Crucial role of the buccal bone. Int J Oral Maxillofac Implants. 2016, 31:1397-1406. 10.11607/jomi.4280

21. Fürhauser R, Florescu D, Benesch T, Haas R, Mailath-Pokorny G, Watzek G: Evaluation of soft tissue around single-tooth implant crowns: The pink esthetic score. Clin Oral Implants Res. 2005, 16:639-44. 10.1111/j.1600-0501.2005.01193.x.

22. Romeo E, Lops D, Amorfini L, Chiapasco M, Vogel G: Clinical and radiographic evaluation of small-diameter (3.3-mm) implants followed for 1-7 years: A longitudinal study. Clin Oral Implants Res. 2006:139-48. 10.1111/j.1600-0501.2005.01191.x

23. Bain CA, Moy PK: The association between the failure of dental implants and cigarette smoking . Int J Oral Maxillofac Implants. 1993, 8:609-15.

24. Romanos GE, Delgado-Ruiz R, Sculean A: Long-term results after immediate loading of platform-switched implants in smokers versus nonsmokers. J Oral Implantol. 2013, 39:691-7. 10.1563/AAID-JOI-D-11-00221

25. Alharethi N: The outcome of smoking on healing of bone around dental implants . J Pharm Bioallied Sci. 2023, 15:760-5. 10.4103/jpbs.jpbs_993_23

26. Karni S, Sela MN, Klinger A: Effect of immediate implant placement on marginal bone loss . Clin Implant Dent Relat Res. 2020, 22:301-7. 10.4103/jpbs.jpbs_306_24

27. Kumar, Abhishek1; Nasreen, Saba2; Bandgar, Subhash3; Bhowmick, Devleena4; Vatsa, Ritesh5; Priyadarshni, Priyanka6. : Comparative Evaluation of Marginal Bone Loss and Implant Failure Rate in Smokers and Nonsmokers. Journal of Pharmacy and Bioallied Sciences 13(Suppl 1):p S203-S206, June 2021. . J Pharm Bioallied Sci. 2020, 12:370-4. 10.4103/jpbs.JPBS_676_20

28. Buser D, Martin W, Belser UC: Optimizing esthetics for implant restorations in the anterior maxilla: Anatomic and surgical considerations. Int J Oral Maxillofac Implants. 2004, 19:43-61. 10.11607/jomi.235

29. Riachi, E., Juodzbalys, G., & Maciuliene, D. (2024).: Clinical Outcomes of Immediate, Early, and Delayed Implant Placement in the Esthetic Zone: A Systematic Review and Meta-analysis. The International journal of oral & maxillofacial implants, 39(5), 157-173. . Int J Oral Maxillofac Implants. 2018, 33:1-17. 10.11607/jomi.10731

30. Papi P, Rosella D, Di Carlo S, Matarazzo F, Pompa G: The influence of smoking on bone healing and bone graft: A review. Clin Ter. 2018, 169:94-98. 10.7417/CT.2018.2070.

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