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Original Article

Comparative Evaluation of Conventional and Socket-Shield Techniques on Maxillary Esthetics Following Immediate Implant Placement in Fresh Extraction Sockets: A Randomized Controlled Trial

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Abstract

Dental implants in fresh extraction sockets of the maxillary esthetic area are technique-sensitive procedures where retaining a buccal root segment can enhance periodontium preservation and esthetics. This study aims to compare marginal bone levels and esthetic outcomes between conventional immediate implant placement and the socket-shield technique in fresh maxillary extraction sockets. Twenty-four patients with type 1 extraction sockets were included in this randomized trial and assigned to either conventional immediate implant placement or the socket-shield technique. Implant survival, crestal bone levels, and pink esthetic scores (PES) were evaluated at 8 months (temporary prosthesis), 12 months, and 36 months (final crowns). All implant-supported restorations were successful within the study's observation period. The socket-shield technique showed significantly lower marginal bone loss (e.g. 1.40 ± 0.29 mm vs. 1.70 ± 0.36 mm at 36 months; $P = 0.040$) and superior PES (e.g., 10.50 ± 0.90 vs. 9.36 ± 0.98 at 36 months; $P = 0.008$) compared to the conventional technique. However, the technique's complexity underscores the need for expertise and careful execution to optimize tissue preservation in the maxillary esthetic zone. The socket-shield technique better preserves hard and soft tissues around implant-retained prostheses than conventional implant placement in maxillary esthetic regions. Further studies with larger sample sizes and longer follow-up are required to validate these findings.

Key words: Extraction socket, Immediate implants, Immediate temporization, Socket shield

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Introduction

Alveolar bone resorption after tooth extraction is a progressive and irreversible natural process. This phenomenon is due to deficient blood supply and loss of bundle bone. This resorption, which leads to significant horizontal and vertical bone loss,

typically occurs within months and can compromise the functional and esthetic outcomes of prosthetic rehabilitation. Immediate implant replacement after atraumatic tooth removal along with guided bone regeneration has been a widely accepted strategy for preserving socket dimensions. However, complete restoration of the lost hard and soft tissue volume remains an elusive goal[1]. It is well understood that the primary cause of alveolar bone loss postextraction is the absence of periodontal ligament, which plays a pivotal role in maintaining the structural integrity of the alveolar ridge [2].

Intentional root submergence below the tissues preserves the hard and soft tissue architecture of the edentulous ridge. Partial extraction procedures involve the removal of a decayed part of the crown and leaving the root submerged below the alveolar ridge. It has changed the imaginative perspective of dental implant prosthetics with successful outcomes. Partial extraction therapies include root submergence, pontic shield, and socket-shield techniques. Root submergence retains the intact root beneath the alveolar ridge to maintain the hard and soft tissue architecture. Pontic shield, used in cases with apical pathology, relies on bone substitutes and soft tissue membranes to contour and develop the pontic site. The socket-shield technique, which involves preserving the buccal portion of the root to maintain the periodontal ligament and bundle bone, has been particularly promising for reducing buccal plate resorption – a physiological remodeling process commonly observed after conventional extraction[3]. Wohrle[4] first described the success of immediate implant after extraction in the anterior maxillary area with provisional which was further substantiated by several studies[5–7]. The procedure preserved the periodontium and maintained the esthetics around implant-supported crown. Hürzeler *et al*. introduced the socket-shield concept, demonstrating its efficacy in retaining buccal bone and mitigating physiological resorption[2]. Subsequent studies have refined the technique and highlighted its potential for enhanced esthetic outcomes in the maxillary anterior region [8]. Several clinical trials have explored the efficacy and esthetic outcomes of immediate implant placement and the socket-shield technique[9–11]. However, the clinical trials of buccal shield methodology are less reported in the literature as the evidence is in the form of case reports and carries negligible scientific value[12]. Despite these advances, several factors influence the success of such techniques, including sagittal root angulation within the alveolar bone, gingival biotype, three-dimensional implant positioning, and restoration contours[13, 14]. The main concern is alveolar/bundle bone resorption after tooth extraction. The grafting procedures in the buccal part of the extraction socket with immediate implant intend to minimize the bundle bone resorption. While partial extraction therapies have shown superior outcomes in maintaining tissue margins, physiological changes in alveolar bone can still lead to suboptimal results[15]. In a recent clinical trial by Ahmed *et al*., the authors compared the vertical and horizontal changes of the buccal cortical bone plates, after employing the socket-shield technique with conventional immediate implant placement and found superior outcomes for the socket-shield group[16]. However, still there is a lack of consensus on the comparative efficacy of these techniques, particularly when juxtaposed with conventional implant placement in fresh extraction sockets due to limited clinical data available. Our randomized controlled trial aimed to address this gap by prospectively evaluating two approaches – conventional immediate implant placement (control) and the socket-shield technique (test) – in the maxillary esthetic region. The study analyzed hard and soft tissue outcomes through pre- and postoperative imaging and pink esthetic scores (PES), contributing to the growing body of evidence on the role of socket shield in preserving peri-implant tissues and achieving optimal esthetic results.

Materials and Methods

Twenty-four patients with type 1 extraction sockets were recruited from the outpatient department of unit of periodontology. All the patients selected were devoid of any systemic medical ailment. The present study was approved by the institutional ethical committee and has been submitted in the clinical trials registry (Ref ID-REF/2024/10/093557).

The sample size for this study was determined using G*Power software, Germany, based on data obtained from a previous study conducted by Abd-Elrahman, Ahmed *et al*[16]. An a priori analysis was conducted to compute the required sample size. The following parameters were given as inputs: A two-tailed test, an effect size (d) of 0.763, a significance level (α) of 0.05, and a desired power of 0.80. The allocation ratio between the two groups (N2/N1) was set to 1. The analysis resulted in a noncentrality parameter (δ) of 2.854, a critical t-value of 2.004, and degrees of freedom (df) of 114. Based on this, the required sample size for each group was determined to be 12, resulting in a total sample size of 24 participants. The actual power of the analysis was found to be 0.8006.

Inclusion criteria

- Age: Adults aged 21–55 years (35.7 ± 1.5)
- Health status: Generally healthy individuals with no significant systemic conditions (the American Society of Anesthesiologists I or II)
- Tooth indication: Single tooth extraction in the maxillary anterior or premolar region, where an immediate implant is indicated
- Bone availability: Sufficient bone volume and quality in the maxillary region to support an immediate implant
- Periodontal health: Good periodontal health with no active periodontal disease (e.g., periodontitis)
- Motivation and compliance: Patients willing to adhere to the study protocol, including follow-up visits and postoperative care
- Consent: Written informed consent was obtained from the patient, indicating understanding and willingness to participate in the trial.

Exclusion criteria

- Systemic conditions: Patients with uncontrolled diabetes, osteoporosis, or other systemic conditions that may affect bone healing or implant integration
- Teeth-related factors: Teeth with widened periodontal ligament, horizontal and vertical root fracture, sites exhibiting facial clinical attachment loss, and insufficient periodontal support
- Smoking: Heavy smokers (>10 cigarettes/day) or those unwilling to reduce smoking during the healing period
- Alcohol/drug abuse: History of alcohol or drug abuse that may impair healing or compliance with the study protocol
- Acute infection: Presence of acute infection at the extraction site (e.g., abscess) that could contraindicate immediate implant placement
- Compromised bone quality: Insufficient bone volume or quality, requiring extensive grafting beyond the standard protocol
- Pregnancy or lactation: Pregnant or breastfeeding women due to potential risks to the mother and child
- Previous implant failure: History of previous implant failure in the maxillary region
- Allergies: Known allergies to implant materials or other materials used in the study
- Other dental treatments: Patients requiring additional complex dental treatments (e.g., orthodontics and extensive restorations) that could interfere with the study outcomes
- Psychiatric conditions: Mental health conditions that may impair the ability to follow instructions or consent to treatment.

The total numbers of patients involved in the study were 24 with an equal share in both groups (12 males and 12 females). All the patients were between the age group of 21–55 years (mean age: 35.7) **(Table 1)**. These participants were randomly assigned to one of two groups: conventional immediate implant placement (control group) or the socket-shield technique (test group). An independent person was assigned from our department to randomly pick an envelope with the mode of treatment written for a new patient agreeing to participate. Parameters were recorded by a separate trained examiner. Examiner involved was calibrated through pilot sessions where they practiced using identical instruments under supervision, and the results are compared until consistent measurements are achieved. Calibration also included repeat measurements on sample cases or phantom models to minimize variations due to subjective judgment.

Table 1. Demographic data

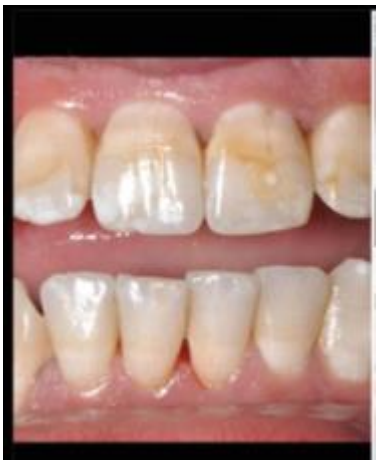
	Patient number	Age (years)	Sex	Tooth restored	Number of implants placed
Test group (socket shield)	1	20	Male	11	1
	2	55	Male	21	1
	3	45	Female	32	1
	4	32	Male	11	1

	5	34	Male	22	1
	6	20	Male	21	1
	7	24	Female	11	1
	8	24	Female	21	1
	9	45	Male	11	1
	10	42	Female	11	1
	11	50	Female	21	1
	12	49	Female	11	1
Control group (conventional immediate implant)	1	24	Female	11	1
	2	33	Female	21	1
	3	43	Male	32	1
	4	27	Male	11	1
	5	20	Male	22	1
	6	25	Male	11	1
	7	32	Female	11	1
	8	36	Female	11	1
	9	49	Female	11	1
	10	53	Female	11	1
	11	55	Male	21	1
	12	22	Male	12	1

The surgical and prosthetic procedures were well explained. Informed consent was taken, and follow-up for the periodic evaluation with the radiographs after the treatment was elaborately explained. After thorough oral hygiene control and with a plaque index score of <5%, the participants were enrolled for the surgery. The occlusion of all subjects was stable with the presence of complete dentition except for the involved tooth. The caries presence and endodontic restorations were completed before the surgeries. All patients underwent radiographic cone beam computed tomography (CT) evaluations to assess good bone levels around neighboring teeth. Local infiltration anesthesia (lignocaine with adrenaline 1: 80,000; Lignox 2%, Warren Indico Remedies Ltd) was used for all procedures.

Among the test group, the condition of the buccal plate of involved teeth was evaluated; the range of thickness was between 0.5 and 1 mm. The patients were asked to rinse with chlorhexidine (0.1%) solution (Dr Reddy Pvt Ltd) before extraction/shield preparation. The socket-shield procedure involved tooth sectioning of the crown and supragingival flattening of the root with conventional diamond bur under running saline irrigation. After measuring the individual root length through a radiograph, the canal was prepared and split mesiodistally with the piezoelectric unit (UltraSurgery, Woodpecker) to reduce damage of mesiodistal alveolar walls. The buccal shield was reduced to the bone crest and was thinned out for a concave profile with a round bur. The width and length of the prepared buccal shield were approximately 1–1.5 mm and 7–9 mm, respectively. The sockets were curetted for remnants/pathology and rinsed with saline solution. The coronal portion of the shield was prepared with an internal bevel for prosthesis apical contours. The periotome helped in pulling out the mobile palatal portion of the root with careful support to the buccal part as no mobility should be felt. The implant osteotomy preparation becomes simple as the buccal root acts as a guide for the direction and precise placement of the implant in the socket. The implants were placed 2–3 mm beyond the apex of the socket-engaging palatal wall, 4 mm from the gingival margins. The gaps between the shield and implants were not grafted. The control group of immediate implant/extraction had supracrestal fibers removed around hopeless teeth with a sharp microblade (Hu-friedy blade) to preserve the periosteal blood supply. After careful tooth extraction and debridement of the socket, implants were placed beyond the apex (2–3 mm) and palatal depending on availability of the bone. The crestal part of the rough implant was kept 4 mm from the gingival margin. In the control group, an atraumatic extraction was carried out using periotomes and forceps to minimize trauma to the surrounding alveolar bone. After tooth extraction, the socket was carefully debrided with curettes and irrigated with a

physiological saline solution. The osteotomy was created in a palatal direction, leaving an approximately 2 mm gap between the implant and the labial bone plate. The implant was positioned 2–3 mm from the gingival margin. Residual jumping gap of >approximately 2 mm were filled with xenograft collagen (Bio–Oss, Geistlich Pharma, Switzerland). For both the techniques, the implants used were from Noris Medical (Tuff TT™). The average width and length of the implants used ranged from 3.3–3.75 to 11.5–13 mm **(Figures 1a-1e, 2a-2e, 3a-3e, and 4a-4d)**.



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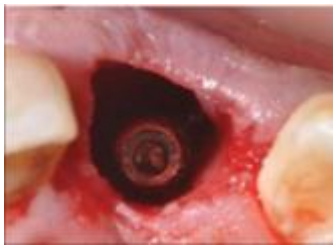

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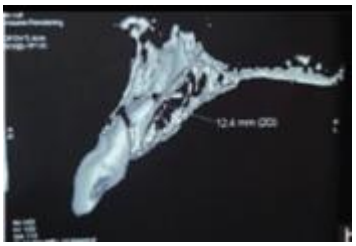

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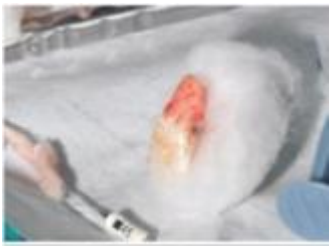

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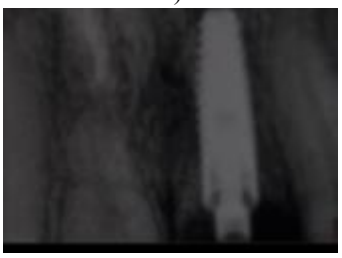
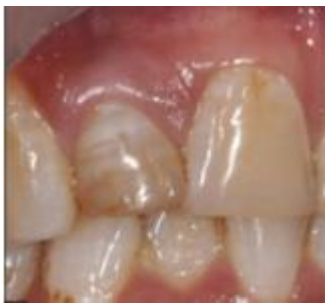


e)

Figure 1. (a) Fractured maxillary left central incisor; (b) cross-sectional view; (c) extracted tooth; (d) implant placed in extraction socket; (e) radiograph after implant placement



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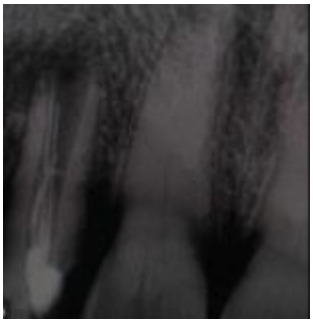

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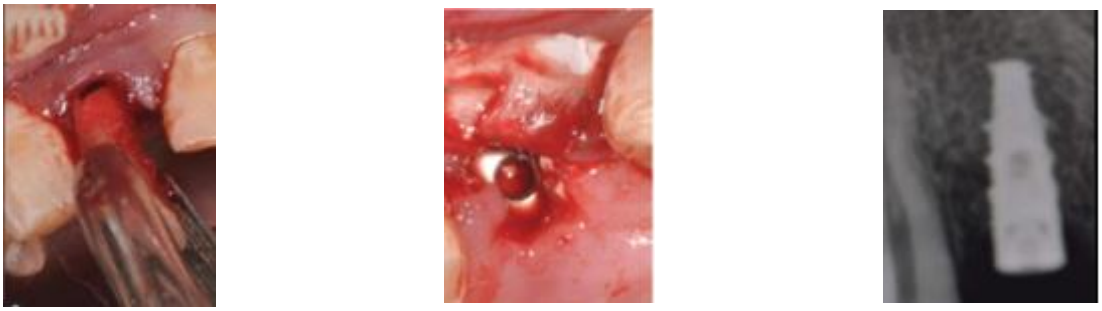
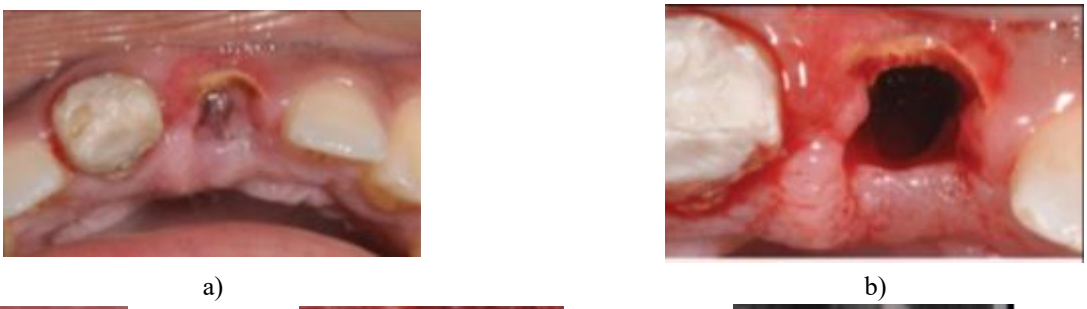


c) d) e)

Figure 2. (a) Infected maxillary right lateral incisor; (b) radiograph of infected maxillary right lateral incisor; (c) extraction of infected maxillary right lateral incisor; (d) implant placed in extraction socket with guided bone regeneration; (e) radiograph after implant placement



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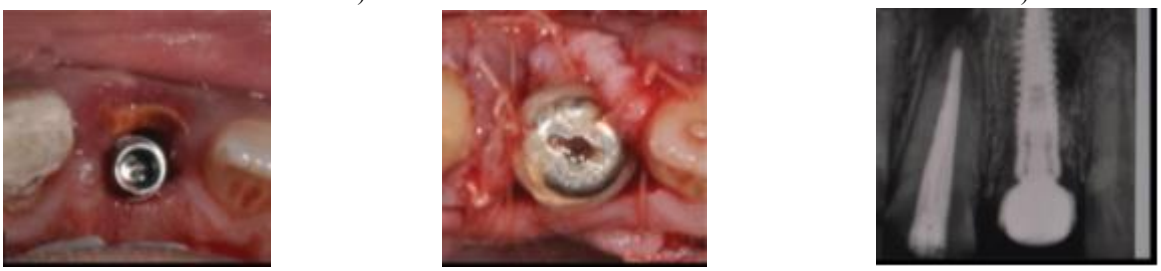
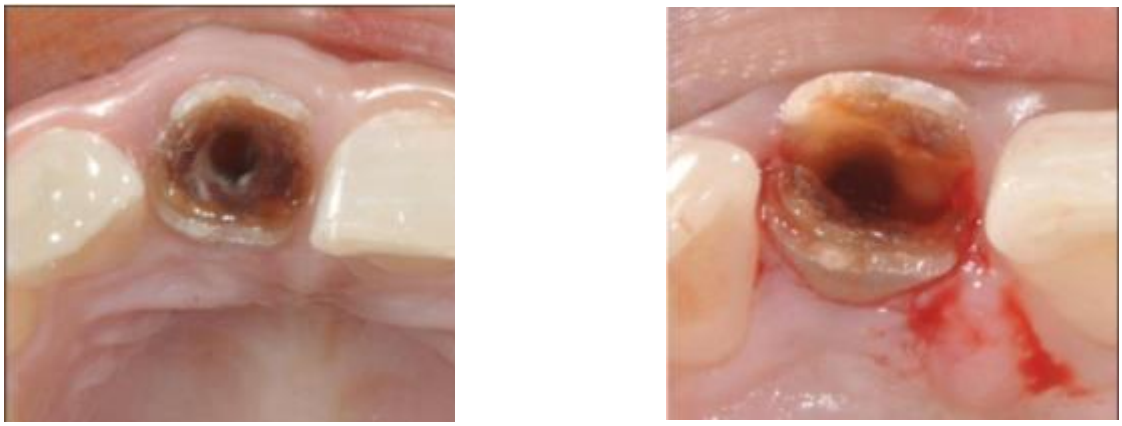


c) d) e)

Figure 3. (a) Fractured maxillary left central incisor; (b) socket shield prepared; (c) implant placed in extraction socket; (d) customized healing abutment on the implant; (e) radiograph after the procedure



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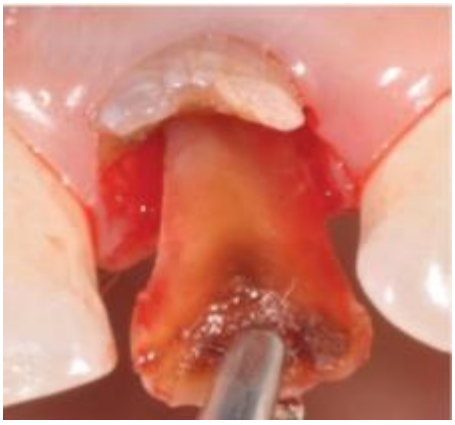

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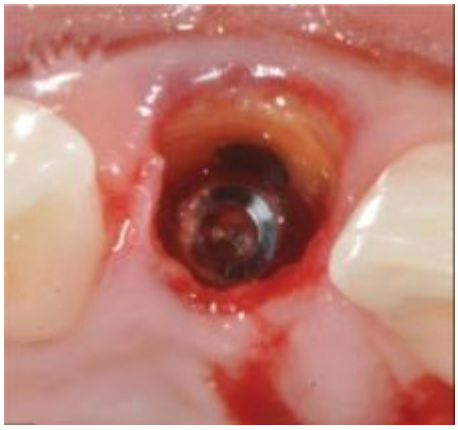
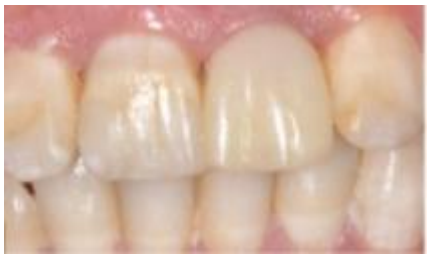


d)

Figure 4. (a) Grossly decayed maxillary left central incisor; (b) tooth sectioning; (c) extraction of palatal part of the root; (d) implant placed in the socket

Out of 24 patients of both groups, 20 subjects achieved adequate torque of 35 N torques on their implants. The direct impressions were taken after screwing the tightening titanium sleeve on the implants. Provisionals were prepared in the laboratories and delivered within 48 h of the surgery. The remaining participants went for impressions after 2 months. Postsurgical instructions had antibiotics (500 mg amoxicillin every 8 h for 5 days) and analgesia as an anti-inflammatory (400 mg ibuprofen) along with chlorhexidine (0.12%) oral rinses twice daily. The patients were advised to use a soft brush around implant implant-retained prosthesis for 2 weeks. Temporary resin crowns on temporary abutments with S-shaped concave subgingival profiles were screwed on the implants for the next 8 months for both groups **(Figures 5a-5d)**. They were discharged from occlusion in both protrusive and lateral movements. There were a few exceptions during the fabrication of the provisional subgingival profile. They were either straight or convex as the few implant trajectories went incisal. The subgingival highly polished concave resin shapes helped in tissue sculpting and maturation around implant-supported restorations. Manipulations for the restorative emergence profile in critical and subcritical areas of subgingival are important for optimizing peri-implant soft tissue architecture. Approximately after 8 months with a temporary prosthesis, crestal bone evaluations were done with radiographs, and soft tissue visual analog estimation was completed for each patient. The final impressions were taken with customized impression copings to precisely replicate all contours of provisional crowns. The definitive screw-retained/bonded crowns either of porcelain or zirconia were delivered to all the participants after protective occlusal verification. The final torque for each implant retained crown was 35 N, and screw access holes were closed with Teflon tapes and flowable composite **(Figures 6a-6d)**. The recall was kept after 1 year of functioning of permanent crowns on the implants and then after 36 months. The crestal bone changes and PES were recorded at each recall **(Figures 7a and 7b, 8a and 8b, 9a and 9b, 10a and 10b, and 11a-11d)**. The patients were advised to visit the department during office hours in between the recall schedule for oral hygiene appointments and implant prosthesis occlusion checks if required.



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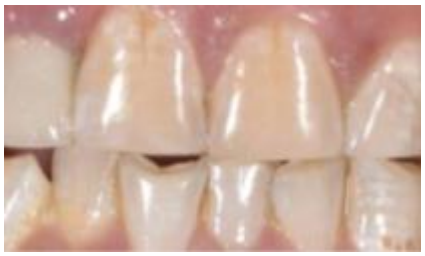

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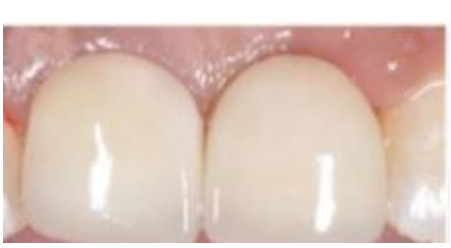
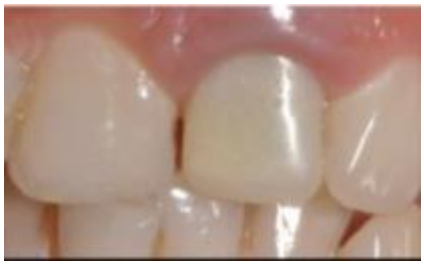
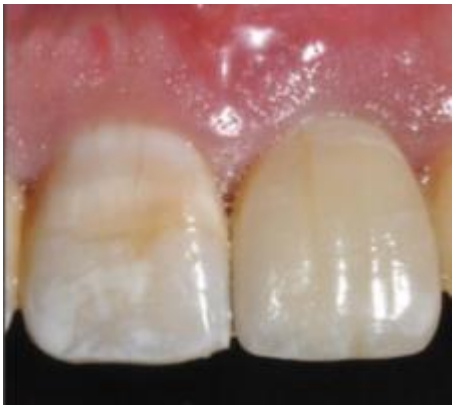
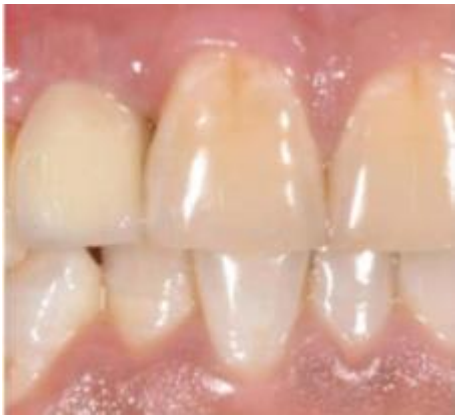




c) d)

Figure 5. (a and b) Temporary prosthesis on the conventional implant procedure (control group); (c and d) temporary prosthesis on the socket shield prepared (test group)





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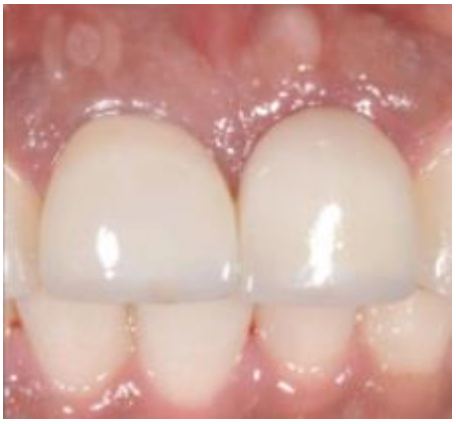
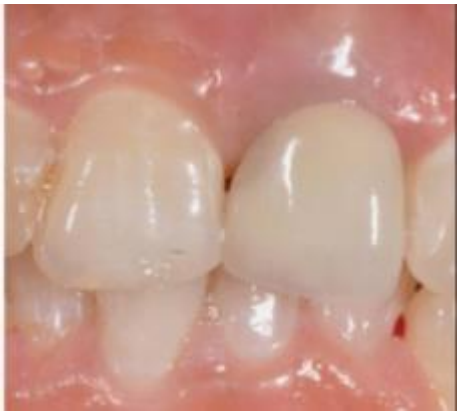
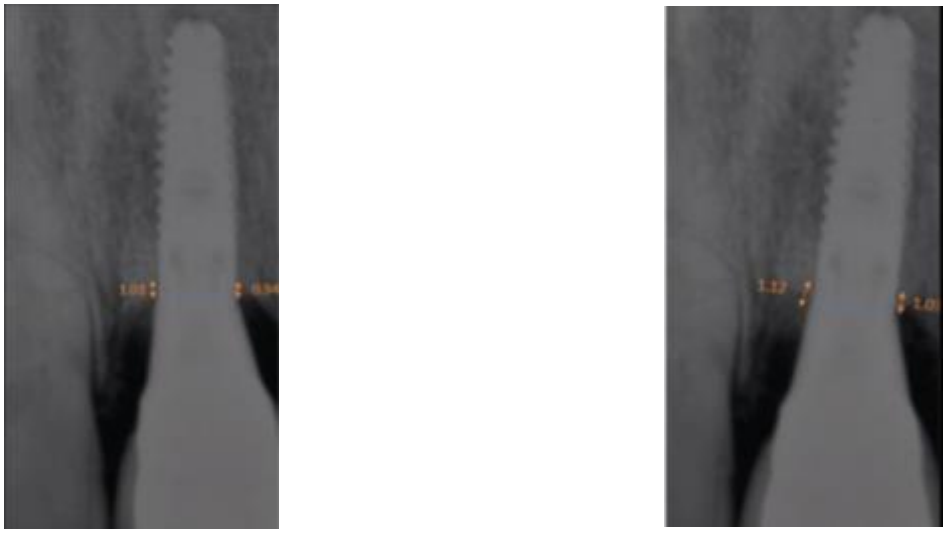




c) d)

Figure 6. (a and b) Final prosthesis on the conventional implant procedure (control group); (c and d) final prosthesis on the socket shield prepared (test group)



a) b)

Figure 7. (a and b) Radiographic evaluation at 12 and 36 months in conventional implant procedure (control group)

a) b)

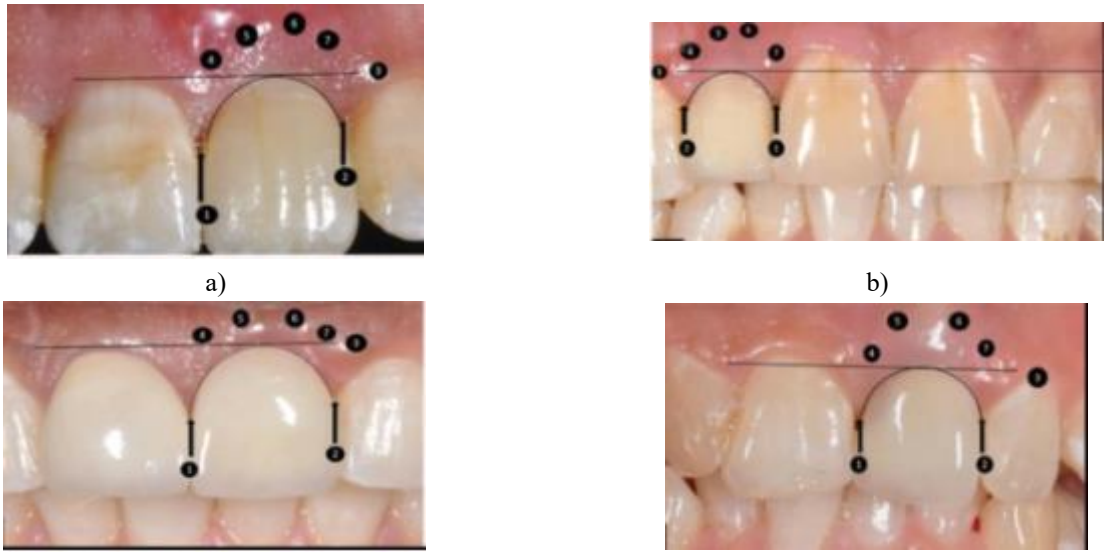
Figure 8. (a and b) Radiographic evaluation at 12 and 36 months in conventional implant procedure (control group)

a) b)

Figure 9. (a and b) Radiographic evaluation at 12 and 36 months in socket shield procedure (test group)

a) b)

Figure 10. (a and b) Radiographic evaluation at 12 and 36 months in socket shield procedure (test group)



a) b)

c) d)

Figure 11. (a and b) Pink esthetic score (PES) evaluation on the conventional implant procedure group; (c and d) PES evaluation on the socket-shield implant procedure GROUP (1-7 depicts the Pink Esthetic Score variables)

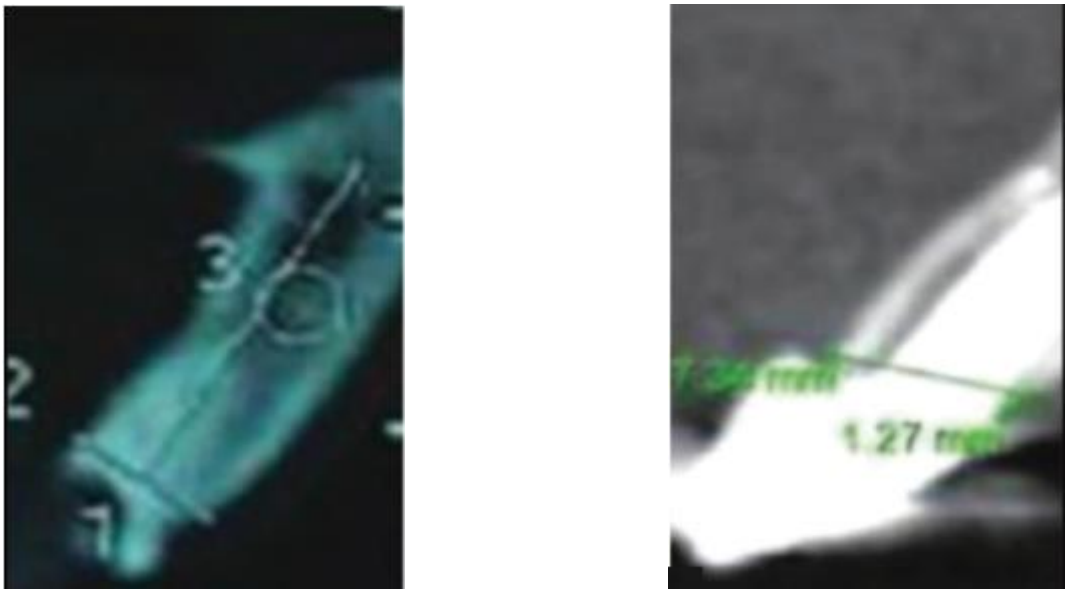
Implants were considered successful with examination of important criteria: (1) absence of clinical mobility, (2) absence of pain, (3) no peri-implant infection, and (4) no radiolucency around implants.

The changes observed in the clinical and radiographic parameters during the study, including marginal bone levels and soft tissue outcomes, were analyzed to indicate bone turnover associated with implant placement and healing, highlighting the dynamic remodeling processes occurring around the implant site, particularly in response to different techniques used for immediate implant placement.

Volumetric analysis for assessment of bone turnover rate is shown in **Figures 12a and 12b, 13a and 13b, 14a and 14b**.

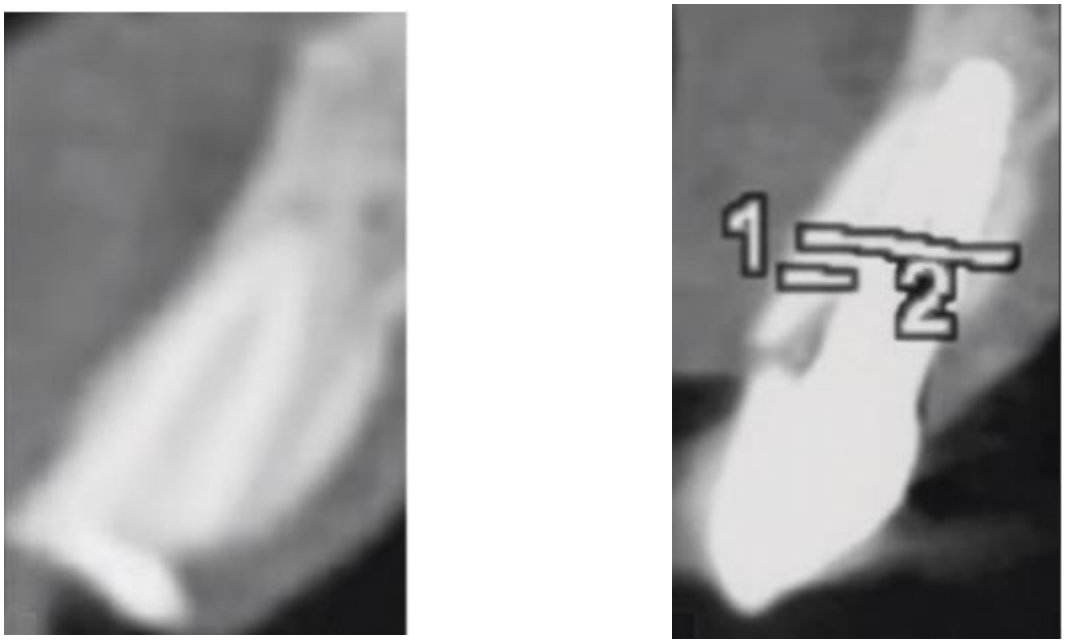
a) b)

Figure 12. (a and b) Postoperative computed tomography showing increased bone thickness buccal to implant after 2 years



a) b)

Figure 13. (a and b) Postoperative computed tomography showing increased bone thickness buccal to implant after 2 years



a) b)

Figure 14. (a and b) Postoperative computed tomography showing increased bone thickness buccal to implant after 2 years

After 2 years of the treatment, each patient underwent a repeat CT. The state-of-the art 64-detector row (500 slice) CT from GE health care, provided ultrafast volume imaging. All routine CT scans were done using ultrathin 0.625-mm slices with volume acquisition and isometric reconstruction. The sagittal views were plotted to measure the bone dimensional changes. The same preoperative slice of the involved tooth was measured in width at a particular position with a postoperative shield retained implant crown. The width measurement was taken in millimeters giving an estimation of hard tissue along with implant in the socket.

Assessment of crestal bone changes

The radiographs were carried out with a Gomax DGT-10 Dental X-ray machine and by VATECH (EzSensor classic) intraoral sensor. The positioning was standardized with RX Intraoral Positioned type XCP which helped in placing the guide bar parallel to the direction of the X-ray beam almost perpendicular to the sensor. Care stream dental imaging system software (CS Imaging version 8) was used for measuring crestal bone changes. The implant platform had a straight line drawn representing height zero. Two traced vertical lines dropped perpendicular to relation of the initial flat line mesial and distal of the implant to the first contact with the bone. The difference between the values of the first measurement and consecutive evaluations established marginal bone loss (MBL).[13] The intervals were kept at 8 months (temporary prosthesis), 12 months, and 36 months (final prosthesis) after final delivery of crowns.

Assessment of soft tissue parameters: Pink esthetic score

PES were evaluated subjectively at the same time intervals (8, 12, and 36 months). PES are the key parameter. PES evaluate several esthetic aspects of peri-implant soft tissues, including:

- Contour of the mucosa
- Color match with adjacent teeth
- Texture of the soft tissue
- Level of the marginal gingiva
- Presence and shape of the papillae.

Each parameter was scored to determine how well the implant site matches the natural appearance of the surrounding dentition.

Statistical analysis

All data analysis was done by the IBM Statistical Package for the Social Sciences (SPSS Version 21.0 Inc., Chicago, IL, USA). Descriptive statistics (mean, standard deviation, median, maximum, and minimum range) were calculated for all the parameters. The Shapiro–Wilk test was used to evaluate the presence/absence of normal distribution and was found to be normally distributed; hence, an unpaired *t*-test was used to compare MBL and PES score. $P < 0.05$ was set as a threshold of statistical significance.

Results and Discussion

Twenty-four patients (12 females and 12 males) were included in the study with an age range of 1–55 (35.7 ± 1.5) years. A total of 24 implants were placed (12 implants in each group) **(Table 1)**. All implants were found to be functioning well after 36 months without any failures.

Radiographic assessments revealed stable crestal bone levels for both the test (socket shield) and control (conventional technique) groups. The evaluation of MBL at different time intervals – 8 months (T1), 12 months (T2), and 36 months (T3) – showed significant differences between the socket-shield technique and the conventional technique groups. At T1 (8 months), the mean MBL in the socket-shield technique group was 0.66 ± 0.37 mm, compared to 1.00 ± 0.42 mm in the conventional technique group, with a statistically significant difference ($P = 0.047$). At T2 (12 months), the socket-shield technique group recorded a mean MBL of 0.98 ± 0.36 mm, while the conventional technique group showed a higher MBL of 1.36 ± 0.40 mm ($P = 0.027$). By T3 (36 months), the mean MBL for the socket-shield technique group was 1.40 ± 0.29 mm, whereas the conventional technique group demonstrated a mean MBL of 1.70 ± 0.36 mm, with the difference remaining statistically significant ($P = 0.040$). These results suggested that the socket-shield technique effectively minimizes MBL over time compared to the conventional technique **(Table 2)**.

Table 2. Evaluation of marginal bone loss (mm) in the two groups at different time intervals

Group	T1	T2	T3
Socket-shield technique	0.66±0.37	0.98±0.36	1.40±0.29
Conventional technique	1.00±0.42	1.36±0.40	1.70±0.36
*P**	0.047	0.027	0.040

P – Probability value; T1 – At 8 months; T2 – At 12 months; T3 – At 36 months **P* < 0.05- statistically significant

The evaluation of the PES at different time intervals – 8 months (T1), 12 months (T2), and 36 months (T3) – revealed significant differences between the two groups. At T1 (8 months), the socket-shield technique group demonstrated a mean PES of 11.04 ± 0.91, while the conventional technique group recorded a lower mean PES of 9.92 ± 0.99, with a statistically significant difference ($P = 0.009$). At T2 (12 months), the socket-shield technique group had a mean PES of 10.77 ± 0.88 compared to 9.65 ± 0.93 in the conventional technique group ($P = 0.006$). By T3 (36 months), the mean PES for the socket-shield technique group was 10.50 ± 0.90, while the conventional technique group recorded 9.36 ± 0.98, maintaining a statistically significant difference ($P = 0.008$). These findings indicated that the socket-shield technique consistently achieved superior PES outcomes over the follow-up period **(Table 3)**.

Table 3. Evaluation of pink esthetic score in the two groups at different time intervals

Group	T1	T2	T3
Socket-shield technique	11.04±0.91	10.77±0.88	10.50±0.90
Conventional technique	9.92±0.99	9.65±0.93	9.36±0.98
*P**	0.009	0.006	0.008

P – Probability value; T1 – At 8 months; T2 – At 12 months; T3 – At 36 months. **P*< 0.05-statistically significant

These findings suggest that the socket-shield technique may offer advantages in both bone maintenance and esthetic outcomes in immediate implant placements.

A two-way repeated measures ANOVA test was applied as there were two groups and two treatment modalities at three time intervals. When treatment and time were considered together, there was no statistically significant difference **(Table 4)**. However, when treatment and time factors alone were considered individually, there was a statistically significant difference **(Tables 5 and 6)**.

Table 4. Two-way repeated measures ANOVA test

Source	Type III sum of squares	df	Mean square	*F*	*P*
Treatment	2.044	1	2.044	5.791	0.035
Error (treatment)	3.882	11	0.353		
Time	6.157	2	3.078	80.212	0.000
Error (time)	0.844	22	0.038		
Treatment × time	0.020	2	0.010	0.579	0.569
Error (treatment × time)	0.382	22	0.017		

F – Test statistics; df – Degree of freedom; P – Probability value

Table 5. ANOVA test for evaluation of pink esthetic score

Treatment	Mean	SE	*P*
Conventional technique	1.358	0.109	0.035
Socket-shield technique	1.021	0.091	

P – Probability value; SE – Standard error

Table 6. ANOVA test using time component of pink esthetic score

Time	Mean	SE	*P*
T1	0.839	0.087	T1 versus T2, *P*=0.000
T2	1.175	0.077	T1 versus T3, *P*=0.000
T3	1.55	0.070	T2 versus T3, *P*=0.000

T1 – At 8 months; T2 – At 12 months; T3 – At 36 months; *P* – Probability value; SE – Standard error

Socket-shield technique showed promising and better outcomes as compared to conventional procedures in our study. The concept of root retention for stabilization of the alveolar form has been mentioned since 1950[17, 18]. This was for complete dentures and fixed dental prosthesis, if the teeth/root stumps were without inflammation[19]. The advantages of the socket-shield technique over the conventional protocol of immediate extraction/implant placement are unpredictable tissue/bone augmentation, which is stressful for the patient and requires additional time. The cost of the surgery decreases as there is no need of regenerative biomaterials. The buccal part of the root acts as guide for correct osteotomy preparation for implant direction and placement. However, there were failures with above-mentioned technique (24.26%) as reported in the systematic review by Gharpure and Bhatavadekar. Other complications mentioned were crestal bone loss (78.78%) and shield exposure (15.5%)[20]. Our study evaluated MBL through standardized intraoral radiographs and the range was between 1.40 ± 0.29 after 36 months with socket-shield patients. Comparing this with conventional immediate implants, it was 1.70 ± 0.36 with the same period of follow-up. There was no shield exposure in any of our cases and bone stability was well maintained. Baumer *et al*. in their volumetric data of 58 months with the socket-shield technique described the MBL around implants in the range of 0.17–0.33 mm, which is comparable with our values.[3] Gluckman *et al*. mentioned that 19% of implants placed with the socket-shield technique experienced minor complications that were resolved in noninvasive manner[21]. Screw retained prosthesis is always advisable with socket-shield procedure as small defects associated can be corrected after unscrewing the implant-retained crowns[22].

Cosyn *et al*.'s in-review analysis of immediate implants in fresh extraction sockets with 60-month duration reported MBL of 0.4–2.06 mm. The values in the observation are almost in accordance with our measurements[23]. Immediate implant in fresh extraction sockets is an accepted protocol that reduces treatment time because the socket heals along with osseointegration. The restoration on these implants can be placed within 48 h without contact with opposite dentition in both centric and eccentric movements with adequate torque achieved[24]. The limitations of the treatment are the possibility of unreliable outcomes with soft and hard tissue healing around implant-supported prosthesis. The evidence regarding soft tissue and esthetic outcomes with patients treated with immediate implant placement/extraction is still inconclusive[25]. According to Cosyn *et al*., in the mean analysis with lower risk cases (thick tissue biotype, >3 mm palatal bone in extraction socket, intact buccal bone >1 mm), there was an advanced mid-facial recession of more than 1 mm (11%). Therefore, careful patient selection criteria should be followed for the procedure. There was loss of papillary changes (0.23 mm–0.27 mm), but there was an improvement with the placement of definitive crowns in our observation as mentioned in a case series with follow-up of 3 years[26]. The gap of >1 mm between the implant and facial bone wall of the extraction socket needs grafting with bone substitutes of slow resorption rate to preserve hard and soft tissue architecture around implant-supported restorations[27]. In a recent systematic review and meta-analysis of Adam Hamilton *et al*., immediate implant placement and immediate loading of single tooth replacement in the maxillary esthetic zone had a high survival rate. The requirements are site specific for standardized outcomes. The local anatomy, clinician skills, long-term esthetics, and patient-reported outcomes should be taken into consideration. The avoidance of contact during centric occlusion and excursive movement should be also avoided with provisional restoration[28].

There are different approaches for tooth preservation and implant-driven prosthetic results like PDL-mediated immediate implant placement and root membrane technique with impressive results in the literature[29, 30]. Both techniques are variants of the socket-shield method with evidence-based results that preserve the buccal bone plate blood supply and dimensions of the alveolar ridge. The latest systematic review for socket shield by Stefano Oliva *et al*. described the technique as beneficial in preserving the buccal bone plate, but because of few randomized control trials, the conclusion should be accepted with caution[31]. Aobo Zhang *et al*. compared the socket-shield technique with the conventional method for immediate implant in the esthetic zone with meta-analysis review. The observation favored the shield technique as the procedure effectively preserved the bone and soft tissue contours around the implant prosthesis with superior outcomes[32]. Socket-shield procedures with implant-supported restorations with growing clinical evidence and histological reports are better than conventional immediate implant procedures in fresh extraction sockets[33].

The PES values for the socket-shield technique were consistently higher at all time intervals compared to the conventional technique, indicating superior esthetic outcomes. This aligns with findings from studies by Gluckman *et al*. and Hürzeler *et al*., which reported enhanced soft tissue stability and esthetics due to the preservation of the buccal root segment and associated periodontal ligament[2, 21]. However, the PES outcomes observed in our study slightly diverged from those reported by Kumar and Kher (2018), where no significant differences were noted between the two techniques[34]. This discrepancy could be attributed to variations in implant positioning, gingival biotype, or differences in prosthetic design protocols. While the socket-shield technique demonstrated improved PES, it is also highly technique sensitive, requiring precise root preparation to avoid complications such as shield mobility or infection. Previous studies, including those by Kan *et al*. (2010), emphasized this challenge, highlighting the steep learning curve associated with the procedure.[13] In addition, the long-term stability of PES in the socket-shield group at 36 months indicates its efficacy in maintaining soft tissue esthetics over time.

Despite advancements in immediate implant placement techniques, several lacunae remain in the field of maxillary esthetics. Long-term clinical studies comparing conventional and socket-shield techniques are limited, with inadequate data on soft tissue stability, peri-implant bone preservation, and patient satisfaction over extended follow-ups. Moreover, the lack of standardized protocols for the socket-shield method leads to variability in outcomes across clinical settings. Comparative studies with larger sample sizes are needed to establish clear guidelines on the selection criteria for each technique. In addition, the biological mechanisms underlying soft and hard tissue preservation in socket shield remain poorly understood, necessitating further research to optimize outcomes and minimize complications.

Conclusion

The comparison of the socket-shield technique and conventional immediate implant placement in fresh extraction sockets within the maxillary esthetic region demonstrated key findings. The socket-shield technique showed better preservation of hard and soft tissues around implant-retained prostheses, providing superior esthetic outcomes compared to conventional techniques. Further studies with larger sample sizes and longer follow-up are required to validate these findings. Given the technique sensitivity of the socket-shield method, its application should be reserved for clinicians with advanced proficiency. The choice between the two approaches should be guided by the clinical scenario, patient-specific factors, and the esthetic demands of the treatment, ensuring alignment with the practitioner's expertise.

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