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Internally Submerged, Tapered, Bone-level Dental Implants in the Anterior Esthetic Region

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Background: Aesthetics is a crucial consideration in the anterior region, alongside dental implant survival and marginal bone loss (MBL). Bone-level implants are advantageous in the esthetic zone as they create a natural emergence profile with the use of customized abutments. This study aimed to assess the esthetic outcomes of internally submerged, tapered, bone-level dental implants and to evaluate associated alveolar bone changes.

Methods: Patients received Luna implants (Shinhung, Seoul, Korea) from 2012 to 2020. MBL was measured immediately after surgery and at 3-month, 6-month, and 1-year follow-ups. Pink and White Esthetic Scores (PES/WES) were evaluated after final restoration and at 6-month and 12-month follow-ups using standardized photographs.

Results: Seventy-eight patients (37 males, 41 females) with a mean age of 73.42 years met the study's inclusion criteria. At the 1-year follow-up, the mean MBL was 0.39 ± 0.74 mm on the mesial aspect and −0.09 ± 0.97 mm on the distal aspect. A statistically significant difference in MBL on the mesial aspect was observed between immediate functional loading and the 12-month follow-up ($P = 0.029$). All implants achieved PES/WES scores of 6 or higher, meeting the threshold for clinical acceptance.

Conclusions: Within the study's limitations, Luna implants demonstrated satisfactory esthetic outcomes and stable bone levels. The results support their use as a viable option for implant placement in the anterior esthetic zone, ensuring both aesthetic and functional success.

Key Words: Bone-level dental implant, esthetics, interdental papilla, Pink and White Esthetic Scores (PES/WES), soft tissue

(*J Craniofac Surg* 2025;36: 1105–1108)

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Received October 12, 2024.

Accepted for publication October 16, 2024.

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This study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of Seoul National University (S-D20200007). All methods were performed in accordance with the relevant guidelines and regulations. The patient was informed of the surgical procedure with the potential risks and benefits, and an informed consent was obtained to receive the treatment and to be included in the study.

Written informed consent was obtained from all individual participants included in the study for publication of this manuscript and any accompanying images.

B.S.-I. and M.Y.E. collected data and wrote this study, K.R.M. contributed to the writing of the manuscript, and H.M. and S.M.K. revised the manuscript.

This study was supported by grant no 04-2024-0131 from the SNUDH Research Fund and Basic Science Research Program through the NRF funded by the Ministry of Education (2022R1I1A1A01070644).

The authors report no conflicts of interest.

Supplemental Digital Content is available for this article. Direct URL citations are provided in the HTML and PDF versions of this article on the journal's website, www.jcraniofacialsurgery.com.

ISSN: 1536-3732

DOI: 10.1097/SCS.0000000000010892

BACKGROUND

Dental implants are an effective solution for tooth replacement. In contemporary dentistry, implant therapy success should not merely be defined by achieving osseointegration, but should include esthetic outcomes, especially in prominent areas like the esthetic zone.[1] The immobility of the implant and the level of marginal bone loss (MBL) are typically regarded as key indicators of success in dental implant treatment.[2] Yet, in the anterior region, mere implant survival and MBL measurements do not guarantee a satisfactory outcome for patients. Especially in frontal locations, aesthetic considerations hold equal importance to functionality. Studies indicate that aesthetic outcomes drive the decision-making process for a significant portion of implant patients, at least 20%.

Two design variations of dental implants have been developed to facilitate the connection between the prosthetic abutment and the implant body. The tissue-level implants feature a transition from a rough to a smooth portion that aligns with the bone level, enabling non-submerged healing. In contrast, bone-level implants are entirely covered by a rough surface and are inserted at the bone level, allowing for submerged healing. Bone-level implants enhance a natural emergence profile through the use of customized abutments, making them especially beneficial in areas where aesthetics are important.[3]

Several objective approaches have surfaced for evaluating aesthetic results, such as the pink and white esthetic score (PES-WES). Studies have emphasized the consistency and repeat-

ability of these measures in assessing aesthetics.[4] Consequently, these assessment techniques have been utilized by researchers to objectively assess and document the aesthetic results of implant restorations, particularly in regions where aesthetics are crucial.[5]

The purpose of this study was to assess the esthetic results of internal submerged, tapered, bone-level dental implants, and evaluating alveolar bone changes.

METHODS

This retrospective study was conducted in accordance with the Helsinki Declaration of 1975 on medical protocols and was approved by the Institutional Review Board of Seoul National University, Seoul, Korea (S-D20200007). From March 2012 to July 2020, a total of 187 internal submerged, tapered, bone-level dental implants (Luna, Shinhung) were placed in the esthetic area of 78 edentulous patients by one oral and maxillofacial surgeon in the Department of Oral and Maxillofacial Surgery at Seoul National University.

Patient Selection

The inclusion criteria were as follows: older than 18 years of age, patients who had one or multiple missing teeth, patients rehabilitated with single-implant-supported crowns, implant-supported fixed dental prosthesis (FDP) in the maxillary and the mandibular esthetic zone, and patients with standard intraoral photos. Maxillary and mandibular esthetic zones were defined as being from and including canine to canine.

The exclusion criteria were as follows: American Society of Anesthesiologists (ASA) physical status class 2 to 6,[6] systemic disease contradicting implant surgery, fully edentulous, patients who received a partial maxillectomy and mandibulectomy, patients who did not come for follow-up, and patients who did not have standard intraoral photographs during the treatment period. Thirty-seven male and 41 female patients who met the inclusion criteria were included in the study, with a mean age of 73.42 years.

Surgical Protocol

Implants were placed in sites with adequate bone height and width, after the protocols defined by the ITI Consensus Conferences: immediate implant placement (type 1), early implant placement after 4 to 8 weeks of soft-tissue healing (type 2), early implant placement after 12 to 16 weeks of partial bone healing (type 3), and late implant placement after complete bone healing of at least 6 months (type 4), based on individual patient indications.[7–10]

Out of 78 patients, 31 had adequate bone height and width for implant placement, whereas 47 patients had inadequate bone height and width, and therefore underwent bone grafting with allogeneic Oragraft (LifeNet Health Co) particulate material. Implants were subsequently installed in the grafted patients after 3 to 6 months, depending on their individual healing progress. Antibiotic medication was administered one day before the surgery and was continued for 4 to 5 days. All of the implant placements were performed under local anesthesia using 2% lidocaine with 1:100,000 epinephrine. Before the creation of a full-thickness crestal incision and flap elevation, the gingival contour and its thickness was assessed at the lingual aspect of the ridge. After the manufacturers drilling sequence and the implants were placed with the self-tapping technique. The flaps were then re-positioned with a tension-free suture. The implants were left submerged (2-stage) for 3 months of healing. The abutment was connected after three months of healing and confirmation of osseointegration by clinical and radiographic assessments.

Photography Protocol

Patients were positioned in a partially reclined posture, ensuring that the occlusal plane was parallel to the ground. A lip retractor was used to display the complete occlusion. Photographs were captured using a Nikon D5500 camera paired with an 85 mm macro lens (Nikon Corporation), operating in manual mode. Lighting was provided by a macro ring flash (Sigma Corporation of America), with no external direct light. The camera settings included an aperture of f/22, ISO 200, and a shutter speed of 1/200, with vibration reduction enabled. The focal length was fixed at the center to standardize magnification, and the white balance was set to auto. Two exposures, including a frontal and an occlusal view, were taken to evaluate alveolar process contours. Care was taken to ensure a horizontal frame orientation. All photographs were taken under standardized lighting conditions to maintain consistency. Post-processing was performed using Adobe Photoshop to adjust brightness, contrast, and color balance, ensuring an accurate representation of the clinical conditions.

Esthetic Outcomes

For esthetic evaluation, standardized intraoral photographs were taken after the final restoration and at the 6-month and 12-month follow-ups to assess both the gingiva and the restoration supported by the implants. The assessment used the PES and the WES.

The PES was composed of 5 variables: mesial papilla, distal papilla, facial curvature, root convexity/soft-tissue color, and texture. Completeness or absence of the mesial and distal papilla was noted, although other variables were compared with a reference tooth, either in the anterior or premolar region. Each variable was rated on a scale of 0 to 2, with 0 indicating the worst and 2 indicating the best results. Therefore, a maximum PES score of 10 represented optimal peri-implant soft-tissue condition, with a score of $\geq$ 6 considered clinically acceptable.[11]

WES assessment included five parameters: general tooth shape, surface texture, outline and volume of the clinical crown, shade (hue and value), translucency and characterization. Each parameter was graded on a scale of 0 to 2, with 0 representing the worst and 10 representing the best results. An esthetic assessment of the implant-supported tooth was conducted by comparing it with the contralateral teeth. The evaluation utilized a scale of up to 10 for WES, where a maximum score of 10 indicated optimal resemblance. A score of 6 was considered clinically satisfactory, whereas a score of 9 was indicative of nearly perfect mimicry (Fig. 1A-B).[11]

Implant Survival and Success Rate

Implant survival was defined as the implant remaining in place and supporting the restoration at the latest recall visit, with no indications for its removal.[12] Implant failure was defined as the removal of a dental implant for any reason, including loss of osseointegration, mobility, persistent pain, fracture, or significant bone loss, at one of the most recent follow-up appointments. Successful implants or prostheses were those without any complications. Standardized digital panoramic radiography was obtained using an Orthopantomograph OP100 (Instrumentarium Imaging) after implant surgery (baseline), immediately after loading, at 6 and 12 months' follow-ups after functional loading. MBL was determined using the 2-dimensional measurement mode of INFINITT PACS (INFINITT Healthcare) (Fig. 1C-D).

Statistical Analysis

Data were gathered and analyzed based on the inclusion and exclusion criteria. Statistical examination was carried out uti-

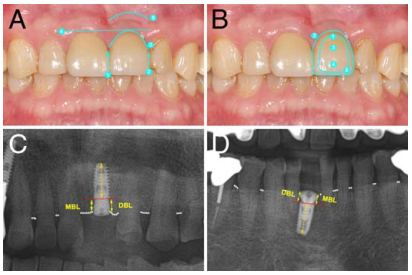

FIGURE 1. Soft-tissue assessment (PES) focuses on the peri-implant soft-tissue condition, assessing 5 variables: mesial papilla (1), distal papilla (2), facial curvature (3), root convexity/soft-tissue color (4), and texture (5). Each variable is rated on a scale from 0 to 2, with a maximum PES score of 10 indicating optimal peri-implant esthetics (A). Prosthesis assessment (WES) evaluates the implant-supported restoration compared with the contralateral natural tooth, assessing 5 parameters: general tooth shape (1), surface texture (2), outline and volume of the clinical crown (3), shade (4), and translucency and characterization (5). A maximum WES score of 10 represents optimal esthetic integration (B). A panoramic radiograph showing mesial bone loss (MBL) and distal bone loss (DBL) measurements around the maxillary #21i implant (D). A panoramic radiograph showing MBL and DBL measurements around the mandibular #41i implant (D). PES indicates Pink Esthetic Score; WES, White Esthetic Score.

lizing IBM-SPSS version 25 (IBM Corp). Student t test was performed to identify statistical significance. A significance level of < 0.05 was established with regard to the P-value.

RESULTS

Demographic Data

A total of 78 (37 males and 41 females) patients who met the inclusion and exclusion criteria were selected for further study. Because of the retrospective nature of the study, most patients excluded from the analysis lacked standard clinical photographs during the follow-up period. Patients age ranged from 37 to 87 years with a mean age of 73.42 years. All implants resulted in successful osseointegration and clinically healthy peri-implant soft tissue at the follow-ups. None of the implants failed. Out of 187 implants, 124 had screw-retained restorations, whereas 63 had cement-retained restorations. Seventy-four implants were rehabilitated with crown restorations (39.57%), whereas 113 implants had FDP (60.43%) restorations (Supplemental table 1, Supplemental Digital Content 1, http://links.lww.com/SCS/H79).

Esthetic Outcomes

The mean PES in this study was 7.95 (range 3.9–9.5, SD ± 1.42) immediately after loading, 7.91 (range 4.3–9.8, SD ± 1.56) at the 6-month follow-up, and 7.89 (range 5.6–9.8, SD ± 1.21) at the 12-month follow-up, which is higher than clinically acceptable. The mean WES was 8.98 (range 7–10, SD ± 0.74) immediately after loading, 8.82 (range 7–9.7, SD ± 0.80) after the 6-month follow-up, and 8.73 (range 7–9.9, SD ± 0.87) at the 12-month follow-up. All of the implant restorations received a WES score of 7 or higher, which translated into higher than acceptable esthetic outcomes (Figs. 2-4). Supplemental table 2,

FIGURE 2. A representative implant-supported 4-unit bridge on #42i and #32i. Preoperative view (A). Immediately after implant installation (B). Occlusal view after functional loading (C). Frontal view after functional loading (D).

FIGURE 3. A representative implant-supported crown on #11i. Preoperative view (A). Intraoperative view during implant installation (B). Frontal follow-up view after healing screw connection (C). Frontal view after functional loading (D).

Supplemental Digital Content 2, http://links.lww.com/SCS/H80 shows the detailed results of the PES and WES analysis after immediate loading. All of the PES and WES were favorable.

No statistical significance was observed between immediate loading, at the 6-month follow-up after loading, and at the 12-month follow-up for either PES and WES scores ($P = 0.066$ and 0.368, respectively) (Supplemental table 3, Supplemental Digital Content 3, http://links.lww.com/SCS/H81).

Implant Success and Survival Rate

The survival rate at the 12-month follow-up after functional loading was 100% based on the International Congress of Oral Implantologists Pisa Consensus implant health scale. The mean MBL on the mesial aspect was 0.01 ± 0.33 mm after functional loading, 0.32 ± 0.80 mm at the 6-month follow-up, and 0.39 ± 0.74 mm at the 1-year follow-up period, respectively. The distal side aspect was −0.04 ± 0.84 mm, −0.06 ± 0.81 mm, and −0.09 ± 0.97 mm after functional loading, at 6-month, and 1-year follow-up, respectively. No significance was observed between the MBL after functional loading and after the 6-month follow-up at the mesial ($P = 0.21$) and distal aspects of the implants ($P = 0.93$). Statistical significance was noted between MBL on the mesial aspect immediately after functional loading and at the 12-month follow-up ($P = 0.029$).

DISCUSSION

Implant-supported restorations represent a reliable treatment approach with a high success rate. Nevertheless, addressing the anterior region poses additional difficulties for clinicians due to its crucial aesthetic considerations. This area is prominently visible during smiling and speaking, and any esthetic imperfections can greatly affect the patient's self-esteem and satisfaction with the treatment results.[13]

In this investigation, data pertaining to pink and white esthetic scores (PES and WES) were extracted to assess the aesthetic results of Luna implants across 78 patients. In addition, a PES/WES index was devised to facilitate the objective evaluation of aesthetics within implant dentistry.[11,14] The findings of this research indicated satisfactory results in both the analysis of PES and WES. The mean PES in this study was 7.89 at the 12-month follow-up, and the WES score was 8.73 at the 12-month follow-up. A previous study by Belser et al[15] revealed PES and WES scores of 8.1 and 8.65, respectively, for 20 single-implant crowns after 1 year in function. The slightly lower PES and WES scores in our present study may be due to the varying factors such as the mixture of immediate and delayed implant

FIGURE 4. A representative implant-supported 2-unit bridge on #22i and #23i. Preoperative view (A). Intraoperative view during implant installation (B). Immediately after healing screw connection (C). Frontal view after functional loading (D).

placements, additional surgical procedures such as bone graft and implant positioning, and the type of restoration such as a single crown or FDP.[15]

Bone-level implants have several advantages over tissue-level implants in the anterior esthetic region, including greater flexibility in abutment selection, improved adaptability for abutment replacement, enhanced space maintenance during guided bone regeneration, better emergence profiles, and design features that improve primary stability and esthetic outcomes.[16] Internal submerged, tapered, bone-level dental implants (Luna, Shinhung) possess these attributes, allowing for optimal esthetic results. Their internal submerged design facilitates a stable platform for precise abutment placement, whereas the tapered shape enhances primary stability and minimizes the risk of bone fenestration. These implants support effective soft-tissue management and contribute to a more favorable emergence profile, ultimately leading to superior esthetic and functional outcomes. In our study, the screws were installed in the cingulum, which is crucial for long-term aesthetic outcomes. Especially with the use of bone-level implants, the cementation procedure requires significant attention and should be carried out with great caution to avoid cement remnants in the mucosa. Whether in the maxilla or mandible, this approach will result in a long-term aesthetic outcome.

This study reports high survival rates of 100% at the 1-year follow-up. Internal submerged, tapered, bone-level dental implants have been shown to exhibit a high survival rate of 97.0% at 10-year follow-ups in medically compromised Korean patients.[17] The esthetic outcomes of dental implants are influenced by changes in marginal bone over time. Peri-implant MBL can result in the loss of interdental papillae and reduction in facial gingival height, potentially leading to patient dissatisfaction and functional failure of the implants.[16] The mean MBL on the mesial aspect was 0.39 ± 0.74 mm at the 1-year follow-up and 0.09 ± 0.97 mm on the distal aspect at the 1-year follow-up, respectively. All implants were installed at the crestal level by the surgeon with the implant collar being located ~1 mm below the crestal level at baseline. The changes in the crestal bone after implant placement and functional loading could be explained with the fact that after functional loading, the crestal bone undergoes a physiological remodeling and resorption process that can alter the bone level up to 2 mm after the first year of loading.[18] When comparing these results with those from the study by Meijndert et al,[19] which investigated bone-level tapered implants in the maxillary esthetic zone, our findings are generally consistent. In their study, the mean loss of marginal bone was 0.07 ± 0.10 mm at 1 year, with an overall gain in papilla height and a high level of patient satisfaction.[19] Our MBL rates, though slightly higher, are within a similar range and indicate stable outcomes over the follow-up period. The differences observed could be attributed to variations in implant design, placement techniques, or patient characteristics between studies. Overall, our study's results align with existing literature, demonstrating that bone-level implants can achieve favorable esthetic and functional outcomes while maintaining marginal bone levels within acceptable ranges over time.

CONCLUSION

This study reveals that Luna dental implants exhibited excellent survival rates and highly satisfactory esthetic results concerning marginal bone preservation and PES/WES findings at the 12-month follow-up after functional loading. In conclusion, Luna dental implants are a reliable treatment of choice for the functional and esthetic rehabilitation of anterior teeth.

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