Five-year esthetic evaluation of implants used to restore congenitally missing maxillary lateral incisors after orthodontic space opening treatment

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Abstract

Objective

This is a five-year follow-up study of a previous investigation with the aim of assessing the esthetic outcome of Morse taper implants used to replace congenitally missing lateral incisors after orthodontic treatment.

Materials and methods

Twenty consecutively treated patients were treated using Morse taper connection implants (Leone Implant System, Leone, Florence, Italy) after orthodontic space opening. The pink esthetic score/white esthetic score index was applied by an independent calibrated examiner to the implant-supported restorations at the five-year recall visit, comparing the esthetic outcome to the previous examinations performed at the three-month and the three-year recall visits.

Results

No implants were lost. All of the implants fulfilled the established success criteria for dental implants with regard to osseointegration and prosthetic complications, with an overall implant–crown success rate of 100%. At the five-year follow-up, the mean distance between the implant shoulder and the first visible bone–implant contact was 0.44 ± 0.14 mm (95% CI: 0.41–0.47), the mean pink esthetic score was 8.35 ± 1.63 and the mean white esthetic score was 8.80 ± 1.00.

Conclusion

The use of single-tooth Morse taper connection implants for replacing congenitally missing maxillary lateral incisors after orthodontic treatment appears to be a successful procedure.

Keywords

Implants, congenitally missing lateral incisors, orthodontic space opening treatment.

Introduction

Dental agenesis is defined as the congenital absence of a tooth bud. It is a condition of unknown etiology, although some theories have been formulated.[1] Its incidence varies among races and sexes. Maxillary lateral incisors are the second most frequent tooth type, after the second premolars and excluding the third molars, affected by this condition.[2] The estimated rate of incidence of congenitally missing maxillary lateral incisors ranges from 5% to 8%.[3] Dental agenesis occurring in the esthetic area has a high impact on smile attractiveness, impairing the smile balance and harmony.[4] Therefore, it must be carefully addressed and requires a team approach.

Classically, congenitally missing lateral incisors can be restored in three ways.[5] A camouflage treatment modality can be performed by mesialization of the canine into the lateral incisor space and performing conservative reshaping of the canine to mimic the incisor.[6] A second treatment possibility is a space opening orthodontic approach, aiming to create adequate space for the placement of an osseointegrated implant in the incisal area or to allow the seating of a fixed partial denture.[5] The third option is orthodontic creation of space in the posterior area to allow the placement of an implant in the premolar area.[7]

Implant therapy is an established treatment modality for the rehabilitation of single or multiple missing teeth with high implant success rates in the long term.[8] Dental implants are able to provide a high esthetic outcome in very demanding clinical situations, such as the rehabilitation of missing teeth in the premaxilla.[9] In the last few years, investigators have focused their efforts on determining a reliable method that is able to evaluate the esthetic outcome of an implant-supported restoration objectively.[10] In the late 1990s, Jemt introduced the papilla fill index for assessing the size of the interproximal gingiva.[11] Recently, Fürhauser et al. proposed an index called the pink esthetic score (PES) that evaluates different aspects of the soft tissue surrounding the implants.[12] Unfortunately, this method focuses only on the outcome of the periimplant tissue and does not consider the restoration. The final esthetic result of implant rehabilitation is the sum of many variables, including the soft tissue, and the restoration plays a pivotal role in the final result.[13] In 2009, Belser et al. introduced the pink esthetic score/white esthetic score (PES/WES), an index able to provide a comprehensive evaluation of the esthetic outcome of an implant-supported rehabilitation.[14] This index allows the clinician to assess either soft-tissue variables or variables related to the restoration itself. A value of 2, 1 or 0 is assigned to every parameter. An evaluation of all of the variables is performed by direct comparison with the natural contralateral reference tooth. Thus, a final score is assigned that estimates the final degree of match or mismatch.[14]

The aim of the present retrospective study is to evaluate the five-year esthetic outcome of a single crown supported by a Morse taper connection implant used to replace a congenitally missing maxillary lateral incisor after orthodontic treatment.

Materials & methods

Patient population

Twenty patients, 11 females and 9 males, with a mean age of 21.33 (range of 19.67–24.17) were identified from the patient chart and included in the study. They had been consecutively treated with Morse taper connection implants owing to congenitally missing maxillary lateral incisors after orthodontic space opening, from 2004 to 2009 at the dental clinic of the University of Insubria (Varese, Italy). Seven patients originally identified did not meet the inclusion criteria and were excluded.

The inclusion criteria were
- presence of natural teeth mesial and distal to the implant
- presence of the contralateral lateral incisor
- adequate bone height and width to place an implant of at least 3.3 mm in diameter and 10.0 mm in length.

The exclusion criteria were
- uncontrolled diabetes
- poor oral hygiene
- active periodontal infections
- bruxism
- smoking habit
- presence of a thin-scalloped gingival biotype.

The biotype was determined by the transparency of a periodontal probe through the gingival mar-

Fig. 1

A lateral incisor at the baseline.

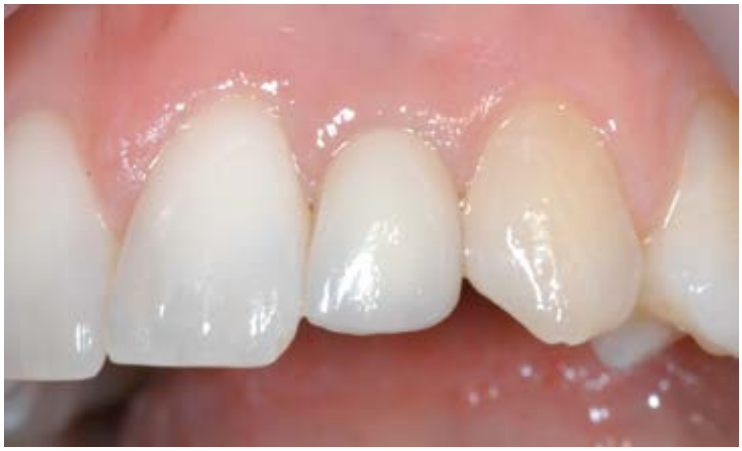


Fig. 2

The implant-supported restoration after five years.

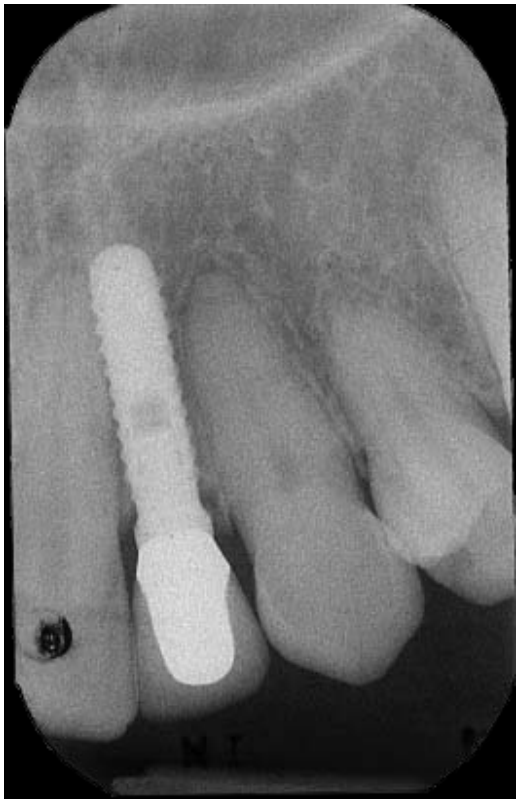
gin while probing the buccal sulcus of the maxillary central incisor.[15] Patients who had undergone implant treatment with hard- or soft-tissue grafting before implant placement and periodontally compromised patients were excluded too. All of the patients read and signed a written consent form for immediate implant placement. The study protocol was conducted in accordance with the Declaration of Helsinki of 1975, as revised in 2007. The local ethics committee approved the study protocol.

Surgical and prosthetic procedure

A complete examination of the oral hard and soft tissue was carried out for each patient, and the implant placement was planned based on clinical and radiographic evaluation. Surgery was performed under local anesthesia, obtained by infiltrating 4% articaine containing 1:100,000 epinephrine (Ubistesin, 3M ESPE, St. Paul, Minn., U.S.). A mesiodistal crestal incision was made and a full-thickness flap was reflected, exposing the alveolar ridge. Preparation of implant sites was carried out with spiral drills of increasing diameter (2.8 mm to place an implant with a 3.3 mm diameter; 2.8 and 3.5 mm to place an implant with a 4.1 mm diameter; an additional 4.2 mm drill was used to prepare the site for an implant with a 4.8 mm diameter), under constant irrigation. Implants were positioned at the bone crest level. The implant system used in this study (Leone Implant System, Leone, Florence, Italy) is characterized by a cone Morse tapered-interference fit locking taper combined with an internal hexagon. The Morse taper has a taper angle of 1.5°.

Temporary abutments were placed and all of the patients received a temporary acrylic resin crown cemented with a temporary cement (TempBond, Kerr, Orange, Calif., U.S.). None of the temporary crowns were in full contact in centric occlusion. The flaps were properly mobilized and repositioned to cover the implants and were secured in position with interrupted sutures (Supramid,Novaxa, Milan, Italy).

Figs. 3 & 4



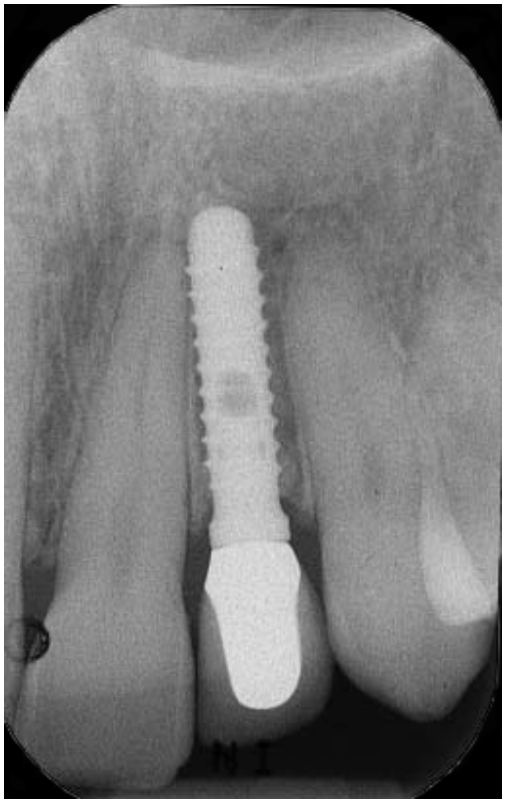


Fig. 3

Radiographic control of the implant at the baseline.

Fig. 4

Radiographic control of the implant after five years.

All of the patients received oral antibiotics (Augmentin, GlaxoSmithKline, Brentford, UK; 2 g per day) for six days. Postoperative pain was controlled by administering 100 mg nimesulide (Aulin, Roche Pharmaceuticals, Basel, Switzerland) every 12 h for two days, and detailed instructions on oral hygiene were given, including mouth rinsing with 0.12% chlorhexidine (Chlorhexidine, Oral-B, Boston, Mass., U.S.) for seven days. Suture removal was performed at eight to ten days. The temporary restorations remained *in situ* for three months, and after this period definitive restorations were placed **(Figs. 1–3)**. All of the single crowns were metal–ceramic and were cemented with a temporary cement (TempBond).

Clinical follow-up examination

Follow-up visits were scheduled at two weeks, as well as one, three and 12 months, during the first year postoperatively and at 24, 36 and 60 months postoperatively. Five years after implant placement, the following clinical and radiographic parameters were assessed at the recall visit: (*a*) presence/absence of pain or suppuration; (*b*) presence/absence of clinically detectable implant mobility; (*c*) presence/absence of prosthetic complications at the implant–abutment interface; (*d*) presence/absence of periimplant radiolucency; and (*e*) distance between the implant shoulder and the first visible bone–implant contact (DIB). Periapical radiographs were taken at the baseline (immediately after implant placement) and at the yearly scheduled follow-up session.[16] Radiographs were taken using a Rinn alignment system (DENTSPLY RINN, Elgin, Ill., U.S.) with a rigid film–object X-ray source coupled to a beam-aiming device to achieve reproducible exposure geometry. Customized positioners made of polyvinyl siloxane were used for precise repositioning and stabilization of the radiographic template.

In order to calculate the DIB, changes in the crestal bone level were recorded as changes in the vertical dimension of the bone around the

Table 1

Detailed PES values for all 20 restorations at the baseline.

Patient	Mesial papilla	Distal papilla	Curvature of facial mucosa	Level of facial mucosa	Root convexity; soft-tissue color and texture	Total PES
1	1	2	2	2	2	9
2	2	2	2	2	2	10
3	1	2	2	2	2	9
4	2	1	1	1	1	6
5	1	1	2	2	1	7
6	1	1	1	1	1	5
7	2	1	1	2	2	8
8	2	2	1	2	2	9
9	2	2	1	2	2	9
10	2	2	2	2	2	10
11	2	2	1	2	1	8
12	2	2	2	2	1	9
13	2	2	1	1	2	8
14	2	1	1	1	1	6
15	1	2	1	2	1	7
16	1	2	2	1	2	8
17	2	2	2	2	2	10
18	2	1	2	1	1	7
19	1	1	2	2	2	8
20	1	2	2	1	1	7
Mean	1.60	1.65	1.55	1.65	1.55	8.00

Table 2

Detailed PES values for all 20 restorations at the three-year follow-up.

Patient	Mesial papilla	Distal papilla	Curvature of facial mucosa	Level of facial mucosa	Root convexity; soft-tissue color and texture	Total PES
1	2	2	2	2	2	10
2	2	2	2	2	2	10
3	1	2	2	2	2	9
4	2	2	1	1	1	7
5	1	1	2	2	1	7
6	1	1	1	1	0	4
7	2	1	1	2	2	8
8	2	2	1	2	2	9
9	2	2	2	2	2	10
10	2	2	2	2	2	10
11	2	2	1	2	1	8
12	2	2	2	2	1	9
13	2	2	1	2	2	9
14	2	1	1	1	1	6
15	1	2	1	2	1	7
16	1	2	2	1	2	8
17	2	2	2	2	2	10
18	2	1	2	1	1	7
19	1	1	2	2	2	8
20	1	2	2	1	0	6
Mean	1.65	1.70	1.60	1.70	1.45	8.15

Table 3

Detailed PES values for all 20 restorations at the five-year follow-up.

Patient	Mesial papilla	Distal papilla	Curvature of facial mucosa	Level of facial mucosa	Root convexity; soft-tissue color and texture	Total PES
1	2	2	2	2	2	10
2	2	2	2	2	2	10
3	2	2	2	2	2	10
4	2	2	1	1	1	7
5	2	1	2	2	1	8
6	1	1	1	1	0	4
7	2	2	1	2	2	9
8	2	2	1	2	2	9
9	2	2	2	2	2	10
10	2	2	2	2	2	10
11	2	2	1	2	1	8
12	2	2	2	2	1	9
13	2	2	1	2	2	9
14	2	2	1	1	1	7
15	1	2	1	2	1	7
16	2	2	2	1	2	9
17	2	2	2	2	2	10
18	2	1	2	1	1	7
19	1	1	2	2	2	8
20	1	2	2	1	0	6
Mean	1.80	1.80	1.60	1.70	1.45	8.35

Table 4

Detailed WES values for all 20 restorations at the baseline.

Patient	Tooth form	Tooth volume	Tooth color	Surface texture	Translucency	Total WES
1	2	2	2	1	1	8
2	2	2	2	2	1	9
3	2	2	2	1	1	8
4	2	1	1	2	2	8
5	1	2	2	2	2	9
6	1	2	2	2	2	9
7	1	2	2	2	2	9
8	2	2	1	2	1	8
9	2	1	2	2	2	9
10	2	2	2	2	2	10
11	2	1	1	1	1	6
12	1	2	1	2	1	7
13	1	2	2	1	2	8
14	2	2	2	2	2	10
15	2	1	2	2	1	8
16	2	1	1	2	2	8
17	1	1	1	2	2	7
18	2	1	1	2	1	7
19	2	2	1	1	0	6
20	2	2	2	2	2	10
Mean	1.70	1.65	1.60	1.75	1.50	8.15

Table 5

Detailed WES values for all 20 restorations at the three-year follow-up.

Patient	Tooth form	Tooth volume	Tooth color	Surface texture	Translucency	Total WES
1	2	2	2	1	2	9
2	2	2	1	2	2	9
3	2	1	2	1	1	7
4	2	1	1	2	2	8
5	1	2	2	2	2	9
6	1	2	2	2	2	9
7	1	2	2	2	1	8
8	2	2	2	2	2	10
9	2	1	2	2	2	9
10	2	2	2	2	1	9
11	2	2	2	2	2	10
12	1	2	1	2	1	7
13	2	2	1	2	2	9
14	2	2	2	2	2	10
15	2	1	2	2	1	8
16	2	1	1	2	2	8
17	2	1	2	2	2	9
18	2	2	1	2	1	8
19	2	2	2	1	1	8
20	2	2	2	2	2	10
Mean	1.80	1.70	1.70	1.85	1.65	8.70

Table 6

Detailed WES values for all 20 restorations at the five-year follow-up.

Patient	Tooth form	Tooth volume	Tooth color	Surface texture	Translucency	Total WES
1	2	2	2	1	2	9
2	2	2	2	2	2	10
3	2	1	2	1	1	7
4	2	1	1	2	2	8
5	1	2	2	2	2	9
6	2	2	2	2	2	10
7	1	2	2	2	1	8
8	2	2	2	2	2	10
9	2	1	2	2	2	9
10	2	2	2	2	1	9
11	2	2	2	2	2	10
12	1	2	1	2	1	7
13	2	2	1	2	2	9
14	2	2	2	2	2	10
15	2	1	2	2	1	8
16	2	1	1	2	2	8
17	2	1	2	2	2	9
18	2	2	1	2	1	8
19	2	2	2	1	1	8
20	2	2	2	2	2	10
Mean	1.85	1.70	1.75	1.85	1.65	8.80

implant, so that an evaluation of periimplant crestal bone stability was gained with time. In order to correct for dimensional distortion in the radiograph, the apparent dimension of each implant (directly measured on the radiograph) was compared with the true implant length, in order to establish with adequate precision the eventual amount of vertical bone loss at the mesial and distal sites of the implant. The DIB was calculated by means of an ocular grid. The established criteria for implant–crown success were as follows: (*a*) absence of pain or suppuration;(*b*) absence of clinically detectable implant mobility; (*c*) absence of periimplant radiolucency; (*d*) a DIB of < 1.5 mm after 12 months of functional loading and of ≤ 0.2 mm for each following year;[17] and (*e*) absence of prosthetic complications at the implant–abutment interface.

Esthetic follow-up examination

In order to examine the esthetic outcome of the implants objectively, intra-oral photographs were critically analyzed using the PES/WES index.[14] All of the implant crowns were photographed with a digital camera (Nikon D100, Nikon, Tokyo, Japan) and a 105 mm lens (AF Micro Nikkor 105 mm 1:2.8 D, Nikon) with a ring flash (Nikon SB-29S Macro Speedlight, Nikon). For assessing anterior tooth replacements, the reference contralateral tooth had to be completely and symmetrically represented in order to ensure comparability. For this purpose, the photographs were centered at the midline, in order to facilitate the subsequent analysis, which was primarily based on symmetry. In addition, standardized clinical photographs were taken of each implant site and of the contralateral tooth **(Figs. 2–4)**. These additional photographs were used as tools for a more detailed evaluation. All of the photographs were taken slightly superior to the occlusal plane, centered at the contact region. Photographs were then viewed on a 42 in. monitor (PPM42S3Q Plasma Display Panel Monitor, Samsung, Seoul, South Korea). Study casts, produced in Type IV stone, were finally fabricated for each of the 20 patients involved in the study. Study casts were fabricated to facilitate a direct and objective assessment related to the PES/WES index.

The clinical photographs and the study casts were used to perform the esthetic evaluation. The esthetic evaluation was performed by an independent calibrated observer who was not part of the treating team, by means of the PES/WES index 1 h after seating of the definitive restoration (three months after implant placement), and three years and five years after implant placement (follow-up), respectively.[18] In order to reduce bias and to achieve good reproducibility, the evaluation was carried out twice, on different days. In the case of diverging scores, the observer carefully re-evaluated the photographs and the study casts prior to making his final decision. A score of 2, 1 or 0 was assigned to each PES/WES parameter. The highest possible PES score was 10, which represented a close match of the periimplant soft-tissue conditions, and the highest possible WES score was 10, representing a close match of the clinical single-tooth crown compared with the respective features of the natural contralateral tooth.

Data analysis

For the PES and WES evaluation, descriptive statistics, including mean values, standard deviations,medians and range, were analyzed. Moreover, in order to compare the differences in PES and WES assessments between the baseline and follow-up, the Wilcoxon rank-sum test for paired data was performed. The level of significance was set at 0.05. All statistical analyses were run on the SPSS statistical package (Version 17.0; SPSS, Chicago, Ill.,U.S.).

Results

Data from 20 patients were examined, with a mean time from surgery to evaluation of five years. No implants were lost. With regard to osseointegration, all 20 anterior maxillary single-tooth implants fulfilled the success criteria, with an implant–crown success rate of 100%. All of the implants showed stable osseointegration, with absence of pain or suppuration, absence of clinically detectable implant mobility, absence of periimplant radiolucency, a DIB of < 1.5 mm during the first year of function, and absence of prosthetic complications at the implant–abutment interface. The mean DIB was 0.44 ± 0.14 mm (95% CI:0.41–0.47) at the five-year follow-up.

The five-year PES/WES values are shown in **Tables 1–6**. The mean PES was 8.35 ± 1.63. With respect to the PES index, there was a significant

improvement compared with the baseline and the three-year follow-up *(p < 0.05)*. Six implants scored a perfect PES value at the five-year evaluation,eight of the remainder had a PES of ≥ 8 and only one implant showed an overall PES of< 6. The mean WES was 8.8 ± 1.0. With respect to the WES index, there were no significant differences compared with the baseline and the three-year follow-up *(p < 0.05)*.

Discussion

Implant therapy is a successful procedure in many clinical scenarios and nowadays is a reliable and predictable treatment modality. A number of scientific trials have proved that implants have a high survival rate in the long term.[8, 19, 20] Many investigators have focused on the esthetic outcome of implants in the esthetic area using different loading protocols, but the literature is scarce on objective evaluation of the esthetic results of implants used to rehabilitate congenitally missing lateral incisors.[21]

The survival rates of implants used to restore maxillary lateral incisors are very high, thus offering both the clinician and the patient high reliability in terms of clinical success.[13, 22] Our data demonstrated a 100% implant–crown success rate,showing no implant failure. Furthermore, a stable bone level was observed throughout the observation period. This is a crucial aspect for maintaining long-term function and for achieving an excellent esthetic outcome. Morse taper connection implants have been proved to yield high functional performance owing to the implant–abutment connection stability. When a prosthetic abutment is connected to a fixture, a microgap is created between the components. Microorganisms may grow into this microgap and establish a bacterial reservoir, resulting in an area of inflamed soft tissue facing the implant–abutment interface. The presence of this microgap may thus have a role in the development of periimplant inflammation and bone loss, as demonstrated by previous studies.[23, 24] Our data demonstrated a high PES value of 8.35 ± 1.63, showing significant differences compared with the baseline and the three-year follow-up. Moreover, there were no changes to the mesial and the distal papillae, and the level of the facial mucosa remained stable, showing no recession. For an optimal esthetic result, it is mandatory to preserve the level of the marginal bone around the implant.[21] The main factors hypothesized to be responsible for marginal bone loss include surgical trauma, micromovements of the abutment, the formation of biologic width, and the presence and size of a microgap between the implant and the abutment. It is known that when an abutment is connected to an implant bone loss always occurs.[25] The features of the implant–abutment connection are considered to influence both the mechanics and the biological behavior of implants.[26] The presence of a microgap at the implant–abutment connection may have a direct effect on bone loss.[27] In implants with screw-retained abutments, this microgap can vary in dimension from 40 µm to 100 µm and can be potentially colonized by bacteria, thus generating a chemotactic stimulus sustaining the recruitment of inflammatory cells, and ultimately resulting in inflammation and osteolysis.[27]

The Morse taper connection is able to avoid micromovements, removing de facto one of the reasons for crestal bone resorption. This connection system gives all the advantages of a platform switching design,achieving a horizontal repositioning of the microgap and more space for the establishment of connective tissue; both of these factors play an important role in the maintenance of a biological seal against bacteria that can impair the marginal bone stability.[28] With regard to the WES index, no differences were observed in the present study. After five years of function, the mean DIB was 0.44 ± 0.14 mm, demonstrating that this particular kind of implant connection system is able to guarantee bone stability in the long term, as demonstrated by previous studies.[16, 29]

Conclusion

Within the limits of this study, the use of single-tooth Morse taper connection implants for the restoration of congenitally missing maxillary lateral incisors after orthodontic treatment appears to be a successful procedure, demonstrating *(a)* a high PES value, *(b)* a high esthetic outcome in the long-term and *(c)* a high implant–crown success rate.

Competing interests

The authors declare that they have no competing interests related to this study. No financial support was received for this study.

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