Esthetic evaluation of implants vs canine substitution in patients with congenitally missing maxillary lateral incisors: Are there any new insights?

Agenesis of one or both maxillary lateral incisors is a frequent clinical finding, which affects approximately 2% of the population.[1-4] As orthodontists, we are faced with two treatment options: one is to open space for prosthetic replacement of the missing lateral incisor mostly by an implant-borne crown or to completely close the space by mesialization of the posterior teeth with the canine substituting the missing lateral incisor. Selecting the appropriate treatment approach is a complex decision depending on the patient's existing malocclusion, growth pattern, profile, smile line, and the size, shape, and color of the canines.[5] It is important to consider treatment options that lead to functionally, esthetically and periodontally acceptable results and which remain stable in the long term.

The main advantage of space closure is that the entire treatment is finished together with the orthodontic treatment and that this approach allows the hard and soft tissue architecture to remain in a natural state, which can better respond to the changes over time. On the other hand, the cuspid will need reduction in the incisal-gingival and mesial-distal dimensions, flattening of the labial surface, a steepening of the lingual convexity, bleaching and composite bonding or veneering to mimic the replaced tooth. The dimensions of the bicuspid must be increased mesio-distally and inciso-gingivally, and the lingual cusp will need to be reduced.[6]

The alternative approach consists in space opening by distalizing the canine into its natural position and preparing for prosthetic replacement[7,8], mostly dental implants, which lead to predictable and successful results, especially in patients with healthy and unrestored adjacent teeth that are of normal size and shape.[9-11] However, the implant approach in the esthetic zone, is a technique-and operator sensitive procedure with little room for error in order to avoid complications, such as incomplete papillary fill, alveolar bone loss and gingival discoloration.[12,13] In order to achieve an optimal esthetic and functional result, it is often necessary to establish a coordinated, interdisciplinary approach involving an orthodontist, an oral surgeon or periodontist, and a restorative dentist. The alveolar ridge will often require additional bony and/or soft-tissue bone grafting in order to create a thick periodontal biotype, which can withstand future resorptive processes and to guarantee excellent hard- and soft-tissue stability over time.[14-18] However, it is not possible to completely exclude a potentially developing infraocclusion, especially in patients with poor interincisor stability.[19-22]

An important aspect during treatment planning in patients with congenitally missing upper lateral incisors is to satisfy their esthetic demands best. In 1975 Nordquist and Mc Neill and in 2000 Robertsson and Mohlin evidenced that patients who had undergone orthodontic space closure with canine substitution were more pleased with the esthetic outcome than patients who had been treated with space opening and bridgework. In neither of the two studies single-implants for replacement of the missing lateral incisors were included.[23,24]

In 2014 De-Marchi et al. found no difference in the rating of smile esthetics in patients with implants or space closure by dentists and laypersons when evaluating photographs of the lower facial third, but these images bear the risk of distracting the respondents, especially non-trained laypersons, by lip fullness or skin texture and color.[25]

A retrospective survey of 5 patients who had been treated by orthodontic space closure versus 5 patients treated with implant-borne crowns by Jamilian et al. in 2015 could not evidence any difference in patient satisfaction with the esthetic outcomes, but the sample size was very small and not suited for any statistical analysis.[26]

To our knowledge, the only study which evaluated the esthetic appeal of implant-borne crowns and Maryland bridges versus space closure by canine substitution with intraoral photographs of treated patients, taking dentitions without any missing teeth as controls, is a study by Armbruster and co-workers from 2005. A panel of orthodontist, dentists, and laypersons had to judge the esthetic outcomes of the different treatment modalities. All respondent groups rated prosthodontic replacement of the missing lateral incisors worst.[27,28]

Over the last 10 years, sophisticated surgical techniques, individual abutment designs, and new prosthodontic materials to improve the long-term stability of both white and pink esthetics of implant-borne restorations, have been developed.[8,14-17] Therefore, the purpose of this survey was to determine:

a) if the esthetic appreciation of orthodontists, dentists and laypersons for space closure with canine substitution, space opening and prosthodontic replacement, and for a dentition without any missing teeth, has substantially changed from 2005 to 2015, and

b) if the implementation of the latest improvements in implantology and prosthodontics has lead to an overall improvement of the esthetic outcome of implant-borne crowns for congenitally missing upper lateral incisors compared to the study by Armbruster et al. from 2005.

Methods

A series of 9 intraoral frontal photographs was evaluated by a panel of 87 orthodontists, 100 general dentists, and 100 laypersons. Three clinical examples each for space closure with canine substitution for missing upper lateral incisors, space opening and replacement of the missing lateral incisors with implant-borne crowns, and an orthodontically treated dentition without any missing teeth in central occlusion had to be assessed (Fig 1-9). These 9 examples had been judged as being the best treatment outcomes by a panel of 4 orthodontists and 2 general dentists with more than 25 years of work experience in their field, when filing the authors' archive for records of patients who had finished treatment at least 12 months ago. All patients had signed an informed consent form prior to the beginning of treatment that their records might be utilized for scientific purposes later on. Ethical approval for this case-series survey was obtained by the Board of the Dental Faculty of the University.

The mean age of the respondent groups was comparable with a mean age of 37.9 years (Standard deviation =SD ± 9.4) for orthodontists and 32.2 years (SD ± 8.1) for dentists and at least 6 years of professional experience in their field. The surveyed laypersons (39 years, SD ± 8.7) were patients from the authors' office and their relatives. Informed consent was obtained from all respondents.

No examples of Maryland bridges for prosthodontic replacement were included in this study, as preservation of the alveolar crest with a natural-looking bony contour and perfect emergence profile is crucial for long-term stability of both pink and white esthetics, but hardly achievable with any kind of bridgework.

All photographs were taken 12 to 24 months after the completion of orthodontic treatment and any restorative dental work with the same digital camera with a resolution of 1280 x 960 pixels and matched in size and color using the Dolphin 11.7 version.
Intraoral photographs were printed in 3.5 x 5 inches format with the same inkjet printer on premium quality glossy photo paper, using the 1400-dpi print mode for presentation to the panel. None of the respondents received any additional information about the agenesis or the type of treatment provided.

To measure the esthetic appeal of the treatment results independently of one another, a questionnaire with a fixed set of 7 bipolar adjective pairs for each photograph was used, as suggested by Bishara and Jakobsen.[29] The 7 pairs were good-bad, satisfactory-unsatisfactory, unusual-usal, nice-awful, attractive-unattractive, ugly-beautiful, and pleasant-unpleasant with a ranking from 1 (best) to 5 (worst) for each pair of adjectives. For each of the 9 photographs the best possible score would be 7 and the worst score 35 points. The individual rater was asked to circle the the number which expressed his/her feeling towards the photograph most appropriately at that moment. In order to prevent acquiescence bias, the adjective pairs were arranged according to a random numbers table as described by Armbruster (25, 26). The questionnaires were distributed and completed by dentists and orthodontists attending a national dental/orthodontic meeting, with permission from the organizing committees, and by randomly selected patients and their relatives with different socioeconomic (middle to upper class) and educational background (high-school and university diploma) from the authors' orthodontic office. All respondents were of same race, ethnicity and culture.

The sum for the three photographs in each category (space closure with canine substitution, space opening and prosthetic replacement, no mising teeth) was averaged, and these values were used for data analysis. Normality of data was verified with the D'Agostino-Pearson test and equality of variance was assessed with the Levene test. Subsequently, a repeated measures ANOVA (factor for repeated measures: treatment modality) and Tukey post-hoc tests were performed. All data with a $p<0.05$ were considered statistically significant. Data were expressed as mean (M) ± Standard Error (SE). The Levene test was performed with

SPSS, version 22.0, Chicago, IL, USA, while the other analyses were carried out with GraphPad Prism, version 6.0.

According to the publication by Cohen[30] the sample sizes for an ANOVA which confronts three groups, setting α level at 0.05, a power of 0.8 and a medium effect size, should be n=52. With at least 87 respondents in each group, the analysis has at least a power of 0.8.

Results

1. Intragroup rating:

The esthetic scores for the various treatment options differ significantly between the three respondent groups.

Orthodontists rank the dentition without any missing teeth significantly more pleasing (12.84 +/- 0.43) than both implants (15.9 +/- 0.56; $p<0.0001$) or space closure with canine substitution (17.25 +/-0.51; $p<0.001$). No statistical difference exists regarding their preference for either space opening or closure.

Dentists also prefer a dentition without any missing teeth (13.35 +/-0.49, $p<0.05$) to either space closure with canine substitution (15.38 +/-0.59) or implant-borne crowns (15.12+/ 10.61), but without any statistically different preference between the latter.

Laypersons prefer space closure to space opening (13.97+/-0.53 vs 16.19+/-0.61, $p<0.01$). They judge space closure and canine substitution even better than a dentition without any missing teeth (14.71+/-0.55), although this difference is statistically not significant (Tables I,II).

2. Intergroup rating:

Both dentists ($p<0.05$) and laypersons ($p<0.0001$) prefer space closure with canine substitution to prosthodontic replacement of the missing upper lateral incisors, when compared to orthodontists.

Orthodontists have a significant preference for a dentition without any missing teeth compared to laypersons ($p<0.05$).

No statistically significant difference between the respondent groups was evidenced for the esthetic appeal of implant-borne crowns (Table III).

3. Comparison between our survey and the study by Armbruster et al. (25)

In comparison to the evaluation by Armbruster and co-workers in 2005 (25), the overall scores decreased for all three treatment modalities, except for a slight, but not significant, worsening of the orthodontists' perception of space closure (Table IV).

The greatest and statistically highly significant improvements were evidenced for the esthetic rating of implant-borne crowns in all of the three respondent groups (orthodontists: 15.90±0.56 vs 22.18±0.57, dentists: 15.12±0.61 vs 21.81±0.30; laypersons: 16.19±0.61 vs 21.52±0.58; $p<0.0001$).

Space closure with canine substitution was judged similar by orthodontists and dentists in both studies, while laypersons rated the outcome more esthetically pleasing than in 2005 (13.97±0.53 vs 17.44±0.87; $p<0.05$).

Discussion

In recent times, evaluation among professionals and laypersons regarding esthetic perception of the smile has been performed relatively frequently by expressing a vote on a Visual Analog Scale (VAS), predominantly utilizing either one single computer-manipulated photograph[31-36] or an altered ideal model (drawing) of a smile.[37] Especially respondents without any training might find it difficult to rate these artificial representations of dentofacial features, which may lead to unreliable results. Smile assessments with photographs of the lower facial third bear the risk of distraction by adjacent structures such as nose, lips or skin qualities.[25,33-36]

The intent of our survey was to evaluate differences in the esthetic perception of implant-borne crowns for replacement of congenitally missing maxillary lateral incisors and space closure with canine substitution by a panel of orthodontists, dentists and laypersons by showing intraoral photographs of treated clinical patients to the respondents. To our knowledge the only comparable study, which has utilized intraoral photographs of treatment outcomes in clinical patients with uni- or bilateral agenesis of the upper lateral incisors, is a study by Armbruster et al. in 2005.[27,28] Orthodontically treated dentitions without any missing teeth served as controls. We were interested to know, whether a comparable survey in 2015 would corroborate the findings from 2005. Instead of a VAS ranking, the respondents were asked to express their feelings utilizing 7 pairs of bipolar adjective for each photograph, because former research has shown that raters tend to avoid the far ends of the VAS, regardless of their actual preferences.[38]

The number of respondents in each of the three categories was more homogenous (87 orthodontists, 100 dentists, 100 laypersons) than in the study by Armbruster and co-workers (43 orthodontists, 140 dentists, 40 laypersons) and thus more appropriate for statistical analysis. As in the former study, our respondent sample was not completely random and may not reflect a reliable cross-section of the population, because the orthodontists and dentists were surveyed at two national professional meetings and laypersons were patients and their relatives from the authors' office. Age range and ethnicity of the three respondent groups and work expertise of the dental professionals was comparable, but the socioeconomic background of the surveyed laypersons was different. However, all surveyed laypersons had at least a high-school degree and all were able to afford orthodontic treatment, which in our area is on a completely private basis. Whether the level of education or the socio-economic

status plays a significant role in the perception of esthetics has been subject to intense research, but has only lead to contrasting evidence.[39-43] We doubt that the socioeconomic status of our laypersons group has majorly influenced the results as the differences were mild to moderate. No evaluation of the esthetic perception between male and female respondents was performed, which could be interesting for future surveys, because the existing evidence is conflicting.[44-46]

In all respondent groups we found a significant improvement of all esthetic scores compared to Armbruster et al. in 2005, which means that to date better treatment outcomes can be achieved. Only orthodontists did not perceive recent space closure treatment results as esthetically more pleasing than 10 years ago, probably reflecting that this type of treatment had already achieved great esthetic outcomes in former times.

The greatest improvements between 2005 and 2015 could be evidenced for replacement of missing upper lateral incisors with implant-borne crowns. These statistically highly significant differences ($p<0.0001$) reflect the recent achievements in periodontology, implantology and prosthodontics and in interdisciplinary therapy, which aim at optimizing both pink and white esthetics of implant-borne prosthodontic replacements, especially in the upper incisor area.

In contrast to the study by Armbruster, we could evaluate a trend for orthodontists and dentists to prefer space opening and implant replacement to space closure with canine substitution, although the difference between these treatment options is not statistically significant.

However, both professional groups rate a natural dentition without any missing teeth the most attractive treatment outcome possible. Especially orthodontists have a high preference for a natural dentition, probably because they have developed an extremely keen eye for even very slight deviations from so-called esthetic norms. This preference was already reported in 2005. (Table V, Fig 10).

In our survey, the 100 laypersons seem to have a different perception of dental esthetics compared to orthodontists and dentists, because they rank canine substitution for missing upper lateral incisors as best category, even in front of the natural dentition without any missing teeth, although this trend was not statistically significant. Interestingly, Armbruster et al. reported the same trend in 2005. Previous surveys have already evidenced that the general population is less tolerant to reductions in maxillary lateral incisor width and that the golden proportion of 62% might need to be adjusted to 70-80%, especially when the clinical crown heights are short.[32,47-49] In a study by Pini et al. teeth widths and heights of patients treated with recontouring were found to be larger than those of patients without agenesis.[50,51] According to the authors, this was attributed to the fact that orthodontic treatment with conversion of the canines into lateral incisors usually requires the recontouring of other anterior teeth, such as the central incisors, in order to obtain better harmony of the smile.[26,52] When the laypersons of the current survey were asked why they prefer the esthetic outcome of space closure with canine substitution even to dentitions without any missing teeth, answer like „ the four front teeth appear more equal“, „it looks

more symmetrical“, „the mouth is less toothy” were commonplace. We can deduce that our professional code of esthetics and sense of proportion may differ from laypersons’ and patients’ perception of attractiveness. While orthodontists and dentists are trained to respect the Bolton index, to create “golden” inter- and intradental proportions and to establish perfect gingival contours, our patients might in fact prefer „bigger“or„same size” lateral incisors.

Hence, showing photographs of what professionals consider being “esthetically pleasing treatment results” to patients with missing upper lateral incisors can be of help for improving doctor-patient communication and for better understanding our patients’ expectations. However, apart from mere esthetic considerations, it is also our professional duty to critically inform the patient about any looming potential issues with implant-borne crowns after space opening or multiple veneer restorations after space closure in the long-term – especially as scientific evidence for both treatment types is still lacking.[53]

Conclusion

Although the esthetic outcome of implant-borne crowns replacing missing upper lateral incisors is far more appealing than 10 years ago, esthetic perception and preference for this treatment modality may vary between dental professionals and laypersons.

In the absence of randomized control trials about long-term esthetic and functional stability of existing standard treatment modalities for agenesis of the maxillary lateral incisors, dental professionals should refrain from imposing their esthetic preferences on patients.

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Figure and table legends

Fig 1: Space closure with canine substitution for missing upper right lateral incisor and compensatory extraction of the upper left first premolar. The right canine has undergone enameloplasty, bleaching and composite bonding.

Fig 2: Normal dentition without any missing teeth.

Fig 3: Implant-borne crown replacing the upper left lateral incisor.

Fig 4: Space closure with bilateral canine substitution of the missing maxillary lateral incisors. The maxillary canines have undergone enameloplasty, bleaching and composite bonding.

Fig 5: Bilateral implant-borne crown replacing both maxillary lateral incisors.

Fig 6: Bilateral space closure with canine substitution of the missing maxillary lateral incisors. The canines have undergone enameloplasty, bleaching and composite bonding.

Fig 7: Normal dentition without any missing teeth.

Fig 8: Normal dentition without any missing teeth.

Fig 9: Unilateral implant-borne crown replacing the missing upper right lateral incisor.

Fig 10: Comparison between the judgement of different treatment outcomes in the three respondent groups between 2005 and 2015.

Table I: Means and standard errors (±SE) for respondent's ranking of the photopraphs grouped by treatment options.

Table II: Intragroup mean differences and 95% confidence intervals (CI) of treatment preference.

Table III: Mean differences and 95% confidence intervals (CI) for treatment preference between the different respondent groups.

Table IV: Comparison between the means and standard errors (±SE) for the ranking of the various treatment options among orthodontist, dentists and laypersons.

Table V: Mean differences and 95% confidence intervals (CI) between treatment preference among orthodontists, dentist and laypersons between 2005 and 2015.

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