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ABSTRACT

Statement of problem: Aggenesis of the maxillary lateral incisor is linked to differences in overall tooth size. Thus, the mesio-distal space required for final esthetic restoration in patients with missing one of both maxillary lateral incisors may be smaller.

Purpose. The purpose of this study is to determine if a tooth size discrepancy exists in orthodontic patients with agenesis of the maxillary lateral incisor(s).

Material and methods. Forty sets of dental casts from white orthodontic patients (19 male and 21 female) mean age 15.9 years were collected. All casts had agenesis of one or both maxillary lateral incisors. The teeth were measured with a digital caliper at their greatest mesio-distal width and then compared to a control group matched for ethnicity, age and sex. S One-way repeated measures ANOVA ($\alpha=.05$) was used for statistical analysis.

Results. Males in the test group had significantly smaller maxillary posterior teeth when compared to males in the control group, with differences ranging from 0.28-0.78mm. Females showed significantly smaller maxillary anterior teeth, with differences ranging from 0.22-0.42mm. The remaining maxillary lateral incisor was also significantly smaller (1.27mm difference) in the male and female unilateral agenesis test groups indicating higher incidence of 'peg' laterals when compared to the control group.

Conclusions. Agenesis of one or both maxillary lateral incisors is associated with a tooth size discrepancy. White males experienced smaller than normal posterior maxillary teeth and females showed smaller anterior maxillary teeth.

INTRODUCTION

Prosthodontists, orthodontists, and general dentists frequently encounter difficulties while attempting to restore the occlusion if unilateral or bilateral maxillary lateral incisors are congenitally missing. The substitution of the missing lateral incisor by an implant and a crown, a fixed partial denture and/or mesial movement of the canine are some of the treatment options to be considered. In order to establish the optimal amount of space required for the ideal restoration, the contralateral lateral incisor size can be used as guide for the size of the missing lateral incisor.¹ However, unilateral agenesis frequently present a peg shaped or missing remaining lateral incisor.² In order to determine the appropriate size of the missing lateral incisors, two methods have been suggested: 1) the *Golden Proportion*, which indicates that the lateral incisor should be about 2/3 of the central incisor width, and 2) the Bolton Analysis used to determine the required space for a missing lateral incisor.^{3,4}

A minimum of 6 mm, but ideally 7 mm of space, is usually recommended for an implant in the area of the lateral incisor.^{5,6} Yet, in many clinical situations, where midlines are coincident, canines are in class I relationship, and an ideal vertical overlap and horizontal overlap are established, the space required to restore the maxillary lateral incisor may still be insufficient. A tooth size discrepancy in the mandibular arch could explain this clinical situation.

While many races experience dental agenesis, Caucasians and those of European descent are more often missing maxillary lateral incisors than other races, with a higher incidence in

females^{16,20}. To minimize ethnic variations within the sample population, this paper focused on maxillary lateral agenesis in white participants. Numerous studies have evaluated tooth size and malocclusion,⁴⁻¹⁰ genetics,¹¹⁻¹⁹ gender,^{16, 20, 21} age,¹⁶ and ethnicity,^{16, 20-22} few studies have discussed the relationship between tooth size and agenesis.²³⁻²⁷

Thus, the purpose of this study was to evaluate if a tooth size discrepancy is observed in white orthodontic patients with agenesis of the maxillary lateral incisor(s). The hypothesis is that orthodontic patients with unilateral or bilateral agenesis of the maxillary lateral incisor have smaller than average teeth in the maxilla and/or the mandible when compared to a matched control sample.

MATERIALS AND METHODS

This research was approved by the IRB committee.

Forty sets of dental casts (21 females, 19 males - mean age 15.9 years), with missing maxillary lateral incisors (22 unilateral, 18 bilateral) (Figure 1- A and B), were used as sample. The dental casts were collected from local orthodontic practices, and compared to an equal number of dental casts from a control group matched for ethnicity, age and sex collected from the records at program. The inclusion criteria for the test population was as follows: white patients with unilateral or bilateral agenesis of maxillary lateral incisor(s), permanent teeth in both arches fully erupted (except for the agenesis of one or both maxillary lateral incisors), no evidence of extreme wear, breakdown, or interproximal reduction of any teeth. Pre- and post-treatment dental casts were used for measurement. Post-treatment dental casts were only examined to confirm that no interproximal enamel reduction or enameloplasty had been conducted during treatment. Dental

casts with crowns or mesio-distal restored teeth were rejected due to the modification of tooth structure and size.

The mean age for the test group was 15.93 years (SD=7.12) ranging from 11 to 47 years old, and the mean age for the control group was 15.925 years (SD=6.74). (Table 1) The orthodontic program's computerized charting system (AxiUm©) was used to search for the matching sample test. The mesio-distal widths of each tooth were measured with a high-precision digital caliper (Masel Electronic digital calipers, Bristol, PA), with measurements rounded to the nearest hundredth of a millimeter. (Figure 2) Measurements of teeth on all casts were taken by one investigator.

Statistical Analysis

The male and female dental cast measurements were analyzed separately due to reported tooth-size-differences between sexes.^{16, 20, 21} An independent t-test was used to analyze most of the tooth-width measurements data. The non-parametric Mann-Whitney test was used in cases where the data was not normally distributed, such as the data for male and female maxillary left lateral incisor, female maxillary right lateral incisor and mandibular right central incisor (Tables 2, 4 and 5). The intra-rater version of the Shrout-Fleiss statistic test was used to evaluate the reliability of the investigator's tooth-width measurements.

RESULTS

Patients experiencing agenesis of the maxillary lateral incisor(s) do exhibit smaller than normal tooth size. In the test groups for males and females, all teeth in the maxillary arch were smaller than the control group. However, not all of these differences were statistically significant. (Tables 2 and 4)

Males in the test group had significantly smaller maxillary posterior teeth (first and second premolars and first molar) when compared to males in the control group, with size differences ranging from 0.28-0.78 mm. (Table 2) In the test male sample group with one missing lateral incisor, the contralateral maxillary lateral incisor was also significantly smaller than the control group. The differences between test and control mean mesio-distal tooth widths were 2.09 mm for the maxillary left lateral incisor and 0.96 mm for maxillary right lateral incisor. (Table 2). In the test male group, no differences were found for the anterior teeth when compared to the controls. However, this group showed smaller than average teeth in the mandibular arch, but results were asymmetrical. And mandibular left first premolar, mandibular left lateral incisor, mandibular left central incisor and mandibular right lateral incisor were significantly smaller than the control group's teeth sizes with differences of 0.32 mm, 0.32 mm, 0.32 mm and 0.38 mm respectively. (Table 3)

Females in the test group expressed smaller teeth in the anterior maxilla. They had significantly smaller bilateral maxillary canines and maxillary left central incisor than the control group. The right maxillary lateral incisor was also significantly smaller when the contralateral tooth was missing, with a difference of 1.32 mm when compared to the control group. Even though the maxillary left lateral incisor was 0.7 mm smaller than the mean maxillary left lateral incisor of the control group, the difference was not statistically significant. (Table 4) The only female mandibular tooth smaller than normal compared to the control group was mandibular left lateral incisor, with a difference of 0.25 mm. (Table 5)

Participants in the test group missing one maxillary lateral incisor had the contralateral lateral incisor significantly smaller than normal on average, frequently referred to as peg-shaped. (Figure 1) The average size of a maxillary lateral incisor in the control group was 6.66 mm wide,

but in the test group, the average size was 5.39 mm (difference of 1.27 mm). (Table 6) When males and females were analyzed separately, they both showed statistically significant smaller than normal maxillary lateral incisors.

The Shrout-Winer intra-rater reliability test found a consistency of 0.99419, confirming the test to be extremely reliable.

DISCUSSION

Although clinicians discuss the minimum necessary space for an implant when missing one lateral incisor, the focus should be on determining the ‘appropriate’ space for the implant/restoration. The ‘Golden Proportion’ for the anterior teeth should be taken into consideration when determining the size for the missing lateral incisor.³ Patients with smaller than normal anterior teeth, as shown in the female test sample of this study, may not need the 6.5mm or 7mm space required for an implant,^{5,6} and although appropriate, it may be too large for the lateral incisor when compared to the adjacent tooth.

In this study, the average size of maxillary lateral incisors in the test group was 5.39. This distance is appreciably less than the minimal 7 mm tooth-to-tooth distance traditionally advocated for implant placement.⁶ The 7 mm tooth-to-tooth distance allows for placement of an implant approximately 4 mm in diameter, with 1.5 mm between the implant and adjacent teeth.^{28, 29, 30} With the advent of platform switching and narrow diameter implants, there is growing evidence that less space may be needed for implant placement.^{31,32} A minimal tooth-to-tooth space of 5.5 mm may be acceptable if a 3.5 mm diameter platform switched implant is placed with 1 mm between the implant and adjacent teeth.^{33, 37}

An association between agenesis of maxillary lateral incisors and tooth size was found by Yaqoob et al.²⁶ Mirabella et al.²⁷ found that agenesis of a maxillary lateral incisor was a strong predictor for reduced overall tooth size. On average, the difference in mesiodistal width of the maxillary central incisor was 0.47 mm and that of the mandibular incisors was 0.43 mm. However no control for race and sex were introduced in that study.²⁷

Results of the present study demonstrated that the male group experienced smaller posterior teeth when compared to the control group (maxillary first and second premolars and first molars, while females demonstrated smaller than normal anterior teeth (bilateral maxillary canines and maxillary left central incisor).

It is unclear why the mean size of the female maxillary right central incisor was not statistically significantly smaller than the control, as was shown with the maxillary left central incisor. Larger sample size could have shown a different result. Ballard discovered that 90% of teeth in his sample were not symmetrically sized between right and left sides with differences as much as 0.25 mm.⁸ The present study did not corroborate the Ballard study, but tooth size differences were evident within the dental arches.

Asymmetry in tooth size was also observed in the mandibular arches of male and female test group (Tables 3 and 5). These results may be due to variability within the sample, a small sample size, or they may demonstrate that mandibular teeth are also affected by maxillary agenesis. Because these trends were different between males and females in the present study, one could suggest a sex-linked genetic association between agenesis and tooth size as suspected by Brook,¹⁹ different from Yaqoob's²⁶ study where they found similar results for both sexes.

Both males and females had smaller than average lateral incisors when the contralateral tooth was missing, which confirmed the link between peg lateral incisors and agenesis.^{2, 36} Even

though the present study evaluated mean mesiodistal widths of each tooth within a group, it was interesting to note the large range of maxillary lateral incisor size in cases of unilateral agenesis (2.9 mm-6.95 mm). This demonstrates a wide spectrum in tooth size of the maxillary lateral incisor when the contralateral incisor is congenitally missing.

Although Kokich¹ advocated using the Bolton analysis to determine the appropriate size for the replacement of the missing maxillary lateral incisor, a Bolton analysis was not conducted in this study test group, mainly due to the maxillary lateral incisor agenesis. In retrospect, if the guidelines described by Kokich¹ were followed, then one should divide the sum of the widths of the mandibular anterior teeth by the sum of the available maxillary anterior teeth plus 'x' (the missing tooth) making this ratio equal to the ideal anterior Bolton ratio (0.78). One could then solve for "x". This procedure may work well in patients with appropriately sized anterior teeth.

However, in a population with a suspected tooth size discrepancy, using the ideal anterior Bolton ratio of 0.78, would not characterize such a discrepancy and could suggest that the missing lateral incisor be larger or smaller than 'normal'.⁷ Furthermore, with this equation 'x' (the size of the missing lateral incisor) possibly would not match the present contralateral maxillary lateral incisor, which could mislead the clinician into preparing an incorrect amount of space during treatment for the implant and crown restoration.

The incidence of peg lateral incisors in patients with incisor agenesis has already been documented² and was confirmed in this study. Given the fact that peg laterals are smaller than normal, inclusion of their measurements could have influenced the Bolton analysis results, conferring it unreliable. Likewise, Smith et al. determined that Bolton's ratios best applied to white females,²¹ which also could have negatively affected the results of this study had they been applied to the white males sample.

Although statistically significant, some of the results may not be clinically significant. A tooth size discrepancy of 1.5-2 mm within an arch (0.75-1 mm/side) is deemed clinically significant. Both Proffit and Othman utilized the Bolton analysis to determine this clinical significance.^{36,37} Othman's study was conducted in a sample of orthodontic patients with full complement of teeth, making harder to compare to the present study. Because the present study evaluated the means of each tooth and did not calculate the tooth size discrepancy per patient (as one would perform with the Bolton analysis), it is difficult to determine if the results from this sample are clinically significant. These tooth size reductions may be clinically significant for some patients (1.5-2 mm discrepancy within an arch) but not for others.

The present study does show statistically smaller teeth in patients with agenesis of the maxillary lateral incisor. However, these findings may have variability between patients and depend on specific clinical situations. It is advisable to approach patients with maxillary lateral incisor agenesis on a case-by-case basis, keeping in mind that these patients can have varying patterns of smaller than normal teeth.

This study was limited to white male and female orthodontic patients, thus, to generalize the findings of this study and tooth size discrepancy patterns across races is difficult. The present sample showed significantly smaller teeth in the anterior maxilla of white females and posterior maxillary segments of white males. However, people of African, Hispanic or Asian decent with agenesis of the maxillary lateral incisor(s) may show different tooth size discrepancies or none at all. Future studies are recommended to evaluate these populations.

CONCLUSIONS

Orthodontic patients with unilateral or bilateral agenesis of the maxillary lateral incisor can have smaller than average teeth in the maxilla, mandible or both arches when compared to a control group.

- In males, maxillary lateral incisor agenesis is associated with significantly smaller than average posterior maxillary teeth bilaterally.
- Females with maxillary lateral incisor agenesis demonstrated smaller than normal maxillary anterior teeth, and smaller mandibular left lateral incisors when compared to the control group.
- Male and female orthodontic patients with unilateral agenesis of the maxillary lateral incisor had the contra lateral maxillary lateral incisor significantly smaller than normal, indicating a 'peg' shape. On average, the difference in maxillary lateral incisor size was 1.27mm compared to the controls.

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LEGENDS

Fig. 1. A) Patient Casts of a exhibiting unilateral agenesis of left maxillary lateral incisor, retained left primary canine, left permanent canine in the position of lateral incisor and a peg-shaped right lateral incisor. B) Casts of a patient with agenesis of both maxillary lateral incisors. Maxillary canines are mesialized into the lateral incisors' space.

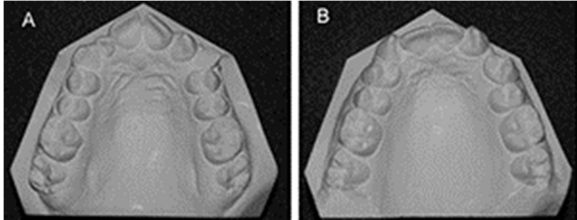


Fig. 2. Digital caliper measuring mesio-distal widths of maxillary teeth. Teeth were measured at their widest point.

