Occlusal characteristics in subjects with or without the ability to roll the tongue

ABSTRACT

Aim The tongue represents an important intraoral muscular force which is in direct contact with the dental arches. The objective of the current study was to compare occlusal characteristics of patients who have the ability to roll their tongue (TR+) to those who cannot (TR-).

Materials and methods A hundred consecutive patients under orthodontic treatment were classified as TR+ (n=73) or TR- (n=27). Pre-treatment orthodontic study casts were used to measure intercanine and intermolar widths, arch lengths, space deficiency, overjet, overbite, presence or absence of posterior crossbite and the molar Angle class. For continuous variables, independent sample t-tests and Mann-Whitney U tests were used to examine differences between the groups. For dichotomous variables, chi-square tests were used to examine differences between groups.

Results TR+ patients showed larger mandibular intermolar widths (1 mm, p<0.05) and less mandibular space deficiency (1.9 mm, p<0.05) than TR- patients. Mandibular space deficiency was present in the mandibular arch in 18.5% of TR+ compared to 49.3% in TR- patients (p<0.05).

Conclusions The ability to roll the tongue may lead to differences in occlusal characteristics, namely an increase in mandibular intermolar width and a less mandibular space deficiency.

Keywords Malocclusion; Occlusal characteristics; Tongue: Tongue rolling.

Introduction

The tongue represents an important muscular force in the orofacial sphere, and it is said to be the most powerful muscle in direct contact with the dental arches [Proffit, 1978; Straub, 1962; Volk et al., 2010]. The tongue is central to the equilibrium theory, and mention of the tongue in this regard can be traced back to Tomes [1873], who referred to the labioliogual frame of teeth stating that “the agency of the lips and tongue is that which determines the position of the teeth”. The equilibrium theory of tooth position has been since revisited and it is still widely accepted that the position of teeth seems to be closely related to the equilibrium resting pressure created by the tongue, the cheeks and lips, as well as that created within the periodontal membrane [Proffit, 1978; Weinstein et al., 1963].

Tongue characteristics such as volume, posture, and function are important in the aetiology of different defining occlusal traits [Ghafari et al., 1988; Hanson and Cohen, 1973; Harvold, 1963; Melsen et al., 1979; Volk et al., 2010]. It has been argued that tongue posture and function are the main aetiological factors in malocclusions [Andrianopoulos and Hanson, 1987; Proffit, 1978; Straub, 1962]. Proffit [2007] suggests that tongue posture may be even more important than tongue function, since the effect of swallowing on the equilibrium of forces acting on the bones and teeth is limited due to the short total duration of these forces daily. Causality as regards tongue posture and function can be questioned however, with the suggestion that these characteristics are a consequence of dental and craniofacial relationships [Cleall, 1965; Subtelny, 1970].

Assessing tongue characteristics clinically is challenging, due to the anatomic structures surrounding it as well as the subjective nature of the evaluation [Volk et al., 2010]. Simple indicators of tongue characteristics may exist, whereby an ability to perform a certain tongue movement such as tongue rolling, may possibly be related to certain occlusal traits.

Tongue rolling is an inherited trait that was first described by Sturtevant [1940] as the ability to turn up the lateral edges of the tongue. It is also known as tongue curling or tongue folding (OMIM 189300). Prevalence of tongue rolling in the general population ranges from 65 to 74%, without gender predilection [Hsu, 1948; Komai, 1951; Liu and Hsu, 1949; Sturtevant, 1940; Urbanowski and Wilson, 1947].

The aim of the present study was to compare occlusal characteristics of patients who have the ability to roll the tongue (TR+) to those who cannot (TR-), due to the importance of the tongue in the orofacial equilibrium. The null hypothesis was that there are no differences in terms of the occlusal configuration between TR+ and TR- children.

Materials and methods

Prevalence estimation

In order to establish the prevalence of tongue
rolling and its age distribution in our local population, a prevalence study was conducted among 590 non orthodontic school children (age range 4-12 years old) attending an annual check-up at the School of Dentistry of the University of Geneva. Children were asked to show the ability to roll the tongue, as shown in a photo of a patient with this ability (Fig. 1). Differences in tongue rolling prevalence based on gender and age were examined using chi-square tests.

**Patient sample**
The study sample consisted of 100 consecutive orthodontic patients under treatment at the Department of Orthodontics of the University of Geneva. Written informed consent had been obtained from all patients and their parents in order to use clinical records for research purposes, and the study was conducted in full accordance with guidelines put forward by the Helsinki Declaration, wherever relevant. Inclusion criteria were the availability of pretreatment diagnostic study casts, taken at the age of 7 or later.

Exclusion criteria were patients with sucking or interposition habits, short lingual frenulum or ankyloglossia, cleft lip and palate patients, syndromic patients, patients with missing permanent teeth and patients who had already undergone an orthodontic treatment. Patients were asked to participate in the study in a consecutive manner during regular orthodontic appointments. Patients accepting to participate were asked to show the ability to roll the tongue as shown in a photo of a patient with this ability, and classified as either TR+ or TR-.

**Occlusal measurements**
Pre-treatment study casts were used to measure the following occlusal characteristics for each of the included patients: intercanine and intermolar widths, presence of posterior crossbite, maxillary and mandibular arch lengths, presence and amount of space deficiency in the maxilla and mandible, molar Angle classification, overjet and overbite. Measurements were performed using digital calipers.

**Statistical methods**
All statistical analyses were carried out with a statistical software package (SPSS for Apple, version 17.0, SPSS Inc, Chicago, Ill, USA). All measured continuous variables were tested for normality with the Kolmogorov-Smirnov test. Independent sample t-tests were used to determine statistically significant differences between groups for the variables which were normally distributed. Mann-Whitney U tests were used when assessing differences in those variables which were not normally distributed. For the measured dichotomous variables, chi-square tests were used to determine statistically significant differences between groups. Statistical significance was set at the p<0.05 level.

**Method error**
Repeated measurement of study casts were performed by the same examiner on 20 randomly selected patients, on two separate occasions one month apart. The error of the method was calculated using Dahlberg’s formula [Dahlberg, 1940], which is defined by \( \sqrt{\frac{\text{d}^2}{2n}} \) (n= number of patients undergoing repeated measurements; d = difference in measurements). The error was found to not exceed 0.8 mm except for space deficiency measurements where it was found to be 1.4 mm.

**Results**

**Prevalence estimation**
The results of the prevalence study are shown in Figure 2. The prevalence of TR+ was 66.4% for the whole sample (n=392/590). No statistically significant differences were found between male and female patients. It was observed that TR+ prevalence was higher in children aged 7 years and older, when compared to those below the age of 7 (p<0.05).

**Tongue rolling and occlusal characteristics**
The study sample consisted of 51 males (mean age: 14.6 years) and 49 females (mean age: 13.6 years). In this sample TR+ was present in 73/100 patients (37/51 males and 36/49 females).

Descriptive statistics and statistical comparisons of measurements performed on dental casts are shown in Table 1. No statistically significant differences were found concerning Angle molar classification. Mandibular intermolar distance showed to be statistically different between the two groups, being 1 mm larger in the TR+ group than in the TR- group (p<0.05). Mandibular space deficiency was 1.9 mm less in the TR+ than the TR- group, this difference being statistically significant (p<0.05).

When recording mandibular space deficiency as a dichotomous variable (present or absent), this was present in 49.3% of TR- patients as compared to 18.5% of TR+ patients (Fig. 3). A chi-square test showed this difference to be statistically significant (p<0.05).
Tongue rolling and arch measures

Prevalence of tongue rolling in schoolchildren aged 4 to 12 years.

Twelve TR+ patients (16.4%) presented with a posterior crossbite compared to five TR- patients (18.5%). A Pearson’s chi-square test failed to show a statistically significant difference between the groups regarding the existence of posterior crossbite.

Discussion and conclusion

The present study suggests that the ability to roll the tongue may lead to differences in occlusal characteristics, namely an increase in mandibular intermolar width and less mandibular incisor space deficiency. The null hypothesis can therefore be rejected. Orofacial function and resting tongue position are reported to play a significant role in the development of posterior crossbite [Proffit, 2007; Thilander and Lennartsson, 2002]. Given that tongue rolling action is expressed in the transverse dimension it could be hypothesized that occlusal transverse differences might be found between TR+ and TR- patients. No differences in the prevalence of posterior crossbite were found between groups however. Mandibular intermolar width, nevertheless, showed a larger width in TR+ patients. Despite statistical significance, the 1 mm decrease in mandibular intermolar distance in TR- patients may not be clinically significant or important enough to create posterior crossbites.

Patients that were TR+ showed less mandibular space deficiency than TR- patients. Although a statistically significant difference was found, the error of the method was rather large (1.4 mm) compared to the difference of 1.9 mm found between groups. The clinical relevance of this finding is thus questionable. When looking at mandibular space deficiency as a dichotomous variable (present or absent) however, a significant difference was again found between groups. Tongue rolling could thus offer a partial explanation for differences observed in mandibular space deficiency. From the anatomical and functional point of view, tongue rolling would seem more closely related to mandibular space deficiency than other associations that have already been established for lower arch dental crowding, such as head posture [Pachì et al., 2009]. One possible hypothesis is that the ability to roll the tongue may be associated with a small increase in the transverse dimension of the mandibular arch and thus a larger arch perimeter would lead to less...
space deficiency.

It has been previously suggested that there may exist a period in which tongue rolling is learned or developed. Komai [1951] found that the prevalence of TR+ changes with age and that only around 50% of children are TR+ before 7 years of age and that prevalence of TR+ stabilizes to normal values at 12 years old. In our prevalence study performed in 590 school children from 4-12 years of age, similar results were obtained. At 7 years of age, the prevalence of TR falls within the same values as described by other authors [Hsu, 1948; Liu and Hsu, 1949; Urbanowski and Wilson, 1947]. Our study sample therefore consisted of patients older than 7 years of age. The prevalence study showed an increase in prevalence that stabilises after the age of 7 years old. Rather than developing the ability to roll their tongue, children below 7 years of age may sometimes be unaware of this ability or are ashamed to show it during clinical examination as we could corroborate. Prevalence of the trait is more reliable when older children are taken into account as was the case with our study sample.

The tongue may be important as regards differences in occlusal characteristics, in aspects such as tongue volume, resting posture, lateral forces, muscular activity and function. The ability to roll the tongue, as is shown in the present investigation, seems to give some but limited insight into differences in occlusal traits. The present study did not attempt to address why occlusal differences exist from a functional viewpoint, or the possible link between the genes responsible for tongue rolling and those controlling specific occlusal characteristics. Given the difficulties in measuring characteristics of the tongue such as size, tongue rolling might be used as a simple indicator of tongue characteristics. Tongue movements require synchronized actions of intrinsic and extrinsic tongue muscles, and exactly which muscles are required to roll the tongue is as yet unknown. Research looking into the anatomical muscle variations between TR+ and TR- patients may be needed in order to better understand tongue rolling and its significance in tongue posture and function, as well as the development of malocclusion. The understanding of muscular activity leading to tongue rolling may help in grasping the complexity of tongue movements and muscular control. Whether this inherited trait is related to muscle tone, swallowing patterns, or functional aberrations of the tongue, such as tongue thrusting, requires further research.

Future studies using tongue rolling as a possible simple clinical indicator of tongue characteristics, may examine aspects such as post-orthodontic stability, or late mandibular arch dental crowding. Differences in stability regarding arch form, arch width, and mandibular arch crowding between TR+ and TR- individuals may provide further insight into tongue function and posture in these two groups of patients. It has been proposed that myofunctional therapy can be useful as an adjuvant to orthodontics in patients with myofunctional dysfunction involving the tongue [Saccomanno et al., 2012a; 2012b].

In conclusion, the present study suggests that the ability to roll the tongue may partly lead to differences in occlusal characteristics, namely an increase in mandibular intermolar width and less mandibular space deficiency. Many other factors however also play a role in the development of occlusal characteristics.

Acknowledgements

The authors acknowledge the help of undergraduate and postgraduate colleagues in the collection of the patient sample. We equally acknowledge Dr. Marie Cornelis for critically reviewing our manuscript.

References