# The prevalence of posterior tongue tie in patients with transverse maxillary deficiency

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*Objectives:* To investigate the prevalence of posterior tongue tie in orthodontic patients using numerical and clinical assessment methods in order to identify an association between posterior tongue tie and transverse maxillary deficiency.
*Materials and methods:* Seventy-nine participants from an orthodontic clinic were divided into two groups. The first group of 44 patients exhibited a skeletally narrow maxilla and required maxillary skeletal expansion (MSE group) and 35 patients without a transverse discrepancy comprised a control group. Posterior tongue tie was examined by the Kotlow tongue tie classification, tongue range of motion ratio (TRMR) and via a clinical assessment. The prevalence of posterior tongue tie was compared between the two groups.
*Results:* There was no significant difference in the level of the Kotlow classification grade between the two groups ($p > 0.05$) and the overall majority was diagnosed as normal. However, a higher proportion of posterior tongue tie was found in the MSE group than in the control group by clinical assessment (MSE group, 72.7%; control group, 42.9%; $p = 0.005$). The proportion of TRMR grade 2 was also higher in the MSE group than in the control group ($p = 0.001$). Of the subjects diagnosed with posterior tongue tie by clinical findings, approximately 94% showed TRMR grades 2 or 3.
*Conclusions:* A clinical assessment of posterior tongue tie was found to be simple and accurate, whereas a numerical assessment alone provided diagnostic difficulty. Considering the high prevalence of observed posterior tongue tie in the MSE group, there was a significant association between posterior tongue tie and transverse maxillary deficiency.
(Aust Orthod J 2021; 37: 294 - 300. DOI: 10.21307/aoj-2021.033)

Received for publication: July, 2021
Accepted: September, 2021

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## Introduction

Tongue tie, or ankyloglossia, is well known to have a negative impact on oral function because of a restriction in tongue mobility.[1,2] Although the prevalence of tongue tie has been assessed by several studies,[2–4] the results have varied because of a lack of a well-validated clinical method for diagnosing the condition.[5]

Tongue tie may be classified as anterior tongue tie, posterior tongue tie, or a submucosal tongue tie based on the connecting area of the lingual frenum.[6] An anterior tongue tie is more common in infants than a posterior tongue tie[7] and is considered easily detected and treatable at an early age. A posterior tongue tie, by contrast, is difficult to detect and diagnose, as it is largely found in teenagers and adults. Few reports have described cases of posterior tongue tie[6,8,9] and little is known about its influence on facial morphology. In addition, whether posterior tongue tie can be evaluated correctly using conventional assessment tools is confused. There is a possibility that a posterior tongue tie has a greater effect on maxillary growth than an anterior tongue tie because of the difficulty of early detection. Although previous studies[10–12] have reported a correlation between a narrow maxilla and tongue tie, the number of patients presenting with

a "posterior tongue tie" in reported studies has been unclear and so the correlation between a transverse maxillary discrepancy and a posterior tongue tie is still unknown. Furthermore, the correlation between a tongue tie and a two-jaw transverse relationship has not been examined in previous studies. It is orthodontically essential to examine, not only maxillary width, but also the two-jaw base transverse relationship before deciding on the need for maxillary expansion.

Dento-alveolar compensation of the upper and lower dental arches (buccal tipping of the upper molar and its alveolar bone, and lingual tipping of the lower molar and alveolar bone), is typically associated with a skeletally narrow maxilla which requires expansion for appropriate maxillary and mandibular decompensation. Recently, a maxillary skeletal expander (MSE; Biomaterials Korea Inc., Seoul, Korea) has been widely applied in patients with a severely narrowed maxilla involving a transverse discrepancy between the jaws.[13–16] The MSE consists of a jackscrew and four temporary anchorage devices which are rigidly attached to the palate, in order to direct an expansion force against an interlocked midpalatal suture, zygomatic buttress and pterygopalatine complex. The MSE is able to expand the entire maxilla from the anterior nasal spine (ANS) to the posterior nasal spine (PNS) and so increase the maxillary basal arch width, even in mature patients.

Clinically, a posterior tongue tie is often observed in patients with a severely narrowed maxilla that would benefit from an expansion procedure. It is considered that a posterior tongue tie may be associated with a transverse skeletal discrepancy, and assessing the level of posterior tongue tie may be a useful diagnostic criterion in managing affected patients.

The present study focused on "posterior tongue tie" in relation to the accuracy of conventional assessment methods and a possible association with a transverse discrepancy. The objectives of the study were: (1) to assess posterior tongue tie in orthodontic patients (with and without maxillary deficiency) by clinical findings and previously established numerical assessment methods; (2) to assess the efficacy of numerical measurements and clinical examination by comparing the observed results; and (3) to identify the association between posterior tongue tie and maxillary transverse deficiency by comparing the prevalence between two groups.

## Materials and methods

### *Subjects*

The 79 participants (52 females and 27 males) were examined in a full-time clinical facility at a single institution. One patient group met the inclusion criteria described below and required maxillary skeletal expansion because of a transverse skeletal deficiency, while a control group without an apparent skeletal discrepancy required orthodontic treatment without maxillary expansion. The exclusion criteria for both groups were: a history of a lingual frenectomy, a craniofacial syndrome, previous orthognathic surgery or significant medical issues. All subjects provided their informed consent prior to their participation. The study protocol was approved by the institutional review board (IRB) of the University of California, Los Angeles.

### *Control group*

Thirty-five patients (25 female and 10 male patients; mean age, 19 years and 4 months; age range, 12 years and 7 months to 42 years and 5 months) who exhibited a malocclusion without a transverse skeletal discrepancy and who therefore did not require maxillary skeletal expansion, were selected. The control group consisted of 14 patients with a class 1 skeletal pattern, 18 with a class 2 pattern and 3 patients with a class 3 pattern.

### *MSE group*

Forty-four patients (27 female and 17 male patients; mean age, 20 years and 0 months; age range, 10 years and 11 months to 43 years and 7 months), were identified. The inclusion criteria for this group were: (1) a diagnosis of a maxillary transverse deficiency, with either a unilateral or bilateral posterior crossbite and associated dental compensation (Figure 1), or according to Andrews' six keys analysis[17]; (2) a need for maxillary skeletal expansion using an MSE appliance; and (3) an absence of previous orthodontic expansion. The MSE group consisted of 15 patients with a class 1 skeletal pattern, 10 with a class 2 pattern and 19 patients with a class 3 pattern.

### *Measurements*

To evaluate the tongue tie and restriction of tongue mobility, the Kotlow classification[18] and the tongue

Figure 1. Transverse discrepancy observed in a patient who was diagnosed of maxillary deficiency and required maxillary skeletal expansion. Maxillary basal arch width was significantly smaller than the lower basal arch width. Dental compensation was often observed in the lower molars.

range motion ratio (TRMR) grade[19] were used (Figure 2). The TRMR was calculated as the ratio of mouth opening distance when the tongue tip was elevated to the maxillary incisive papillae (MOTTIP) relative to the maximal interincisal mouth opening (MIO) distance. All measurements were performed by one examiner.

In addition, a clinical examination of anterior and posterior tongue tie was performed. An anterior tongue tie was defined as a heart-shaped tongue or one in which the lingual frenum was inserted just behind the tip of the tongue. For the assessment of a posterior tongue tie, the patients were asked to elevate their tongue while the floor of the oral cavity lateral to the tongue was passively held down by the examiner. If the patient exhibited limited elevation of the tongue towards the maxilla and showed cupping of the tongue (Figure 3), a diagnosis of posterior tongue tie was made. The percentage of patients who had a posterior tongue tie relative to the total participants in each group was calculated. The Kotlow classification and TRMR grade results were compared with the clinical diagnosis of a posterior tongue tie.

For an evaluation of intra-examiner error, 20 randomly selected patients were measured twice after an interval of one month. Intra-examiner errors of each measurement value were assessed using a paired *t*-test. In addition, Intraclass Correlation Coefficient (ICC) was calculated to measure intra-examiner reliability.

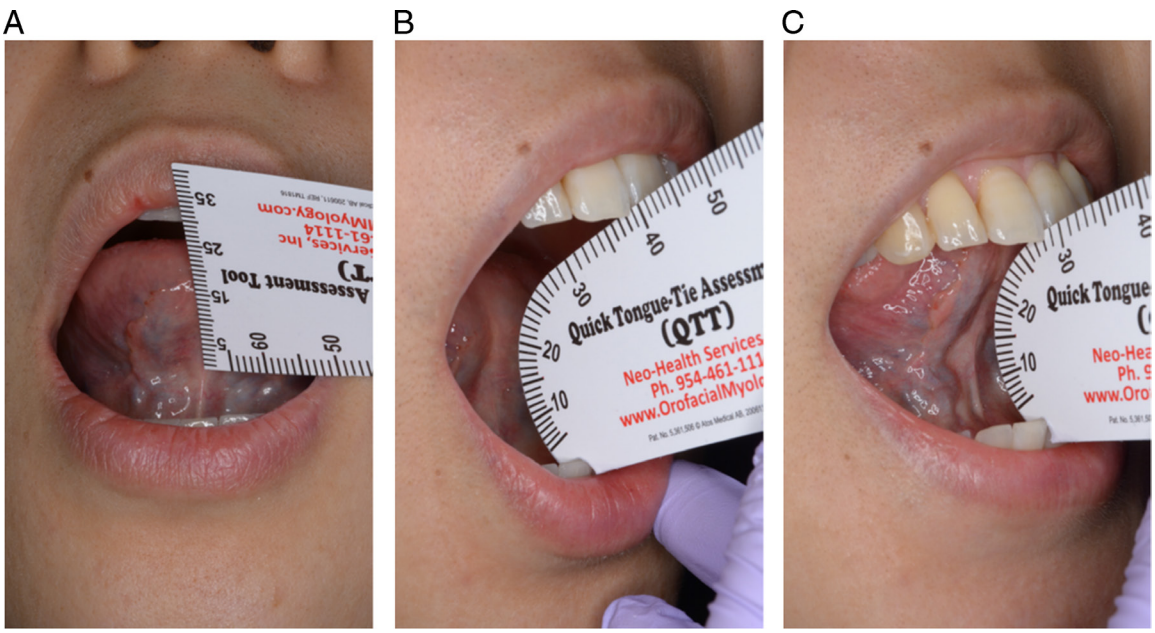


Figure 2. A numerical assessment of the tongue tie and restriction of tongue mobility. (A) Kotlow free tongue measurement, (B) Maximal interincisal mouth opening distance (MIO), (C) Mouth opening distance with elevating tongue-tip up to the maxillary incisive papillae (MOTTIP).

Figure 3. A clinical assessment of posterior tongue tie. The patients with posterior tongue tie showed cupping of the tongue during attempted elevation when the bottom of the tongue was being held down by the examiner.

### *Statistical analyses*

The proportion of each variable between the two groups was compared using Fisher's exact probability test. The statistical analyses were carried out by applying statistical analysis software (IBM SPSS statistics 24, IBM Corp, Armonk, NY, USA). The significance of mean differences was set at the 0.05 level.

A power analysis was performed to determine statistical validity. When it was assumed that the number of the patients affected by a posterior tongue tie would be more than 80% in the MSE group and less than 40% in the control group, the calculation determined that at least 27 patients in each group were required to generate a power of 0.80 and an alpha of 0.05.

## Results

To evaluate reproducibility, an intra-examiner error was calculated. There were no significant intra-examiner errors in any measurement value ($p > 05$). The intra-examiner mean absolute differences in the measurements of the Kotlow classification, MOTTIP and MIO were 1.1 mm, 1.4 mm and 1.7 mm, respectively. The results of the Intraclass Correlation Coefficient and the Kotlow classification, MOTTIP and MIO were 0.96, 0.98 and 0.95, respectively. Therefore, the reliability of the results measured by the single examiner was high. In addition, the clinical findings concerning posterior tongue tie at the first and second measurements matched.

The results of intergroup comparisons of the tongue tie proportion are shown in Table I. There was no significant difference in the proportion of each level of Kotlow classification between the two groups ($p > 0.05$), as a majority of patients in both groups exhibited a normal anterior tongue length. Although the differences between the two groups were not statistically significant, 25% of the patients in the MSE group had a class 1 and 2 level of tongue tie, whereas only 11.4% of those in the control group fell in the class 1 and 2 categories.

In a comparison between the TRMR grade 1 (normal tongue mobility) and grade 2 (mild tongue restriction) categories, significant differences were found between the two groups ($p = 0.001$). The MSE group had a significantly lower proportion (6.8%) than the control group (40.0%) in TRMR grade 1; however, the MSE group had a significantly higher proportion (81.8%) than the control group (57.1%) in TRMR grade 2. No significant differences between the two groups were found for grades 3 or 4 ($p > 0.05$). When the grades 2 and 3 (mild to moderate tongue restriction) were combined, 93.2% of the MSE group and 60.0% of the control group had restrictions, but this difference was not statistically significant.

The clinical examination revealed that there was a significant difference in the number of patients with a posterior tongue tie between the two groups ($p = 0.005$). The MSE group had a significantly greater number of posterior tongue tie patients (72.7%) than the control group (42.9%). Only two patients (4.5%) in the MSE group had an anterior tongue tie.

Table I. The intergroup comparison of proportion of each grade and clinical findings of tongue tie.

| | | MSE group (*n* = 44) | Control group (*n* = 35) | *p*-value |
|---|---|---|---|---|
| Kotlow free toungue measurement | Normal | 33 (75.0%) | 31 (88.6%) | |
| | Class 1 | 10 (22.7%) | 4 (11.4%) | 0.239 |
| | Class 2 | 1 | 0 | |
| | Class 3 | 0 | 0 | |
| | Class 4 | 0 | 0 | |
| TRMR grade | Grade 1 | 3 (6.8%) | 14 (40.0%) | |
| | Grade 2 | 36 (81.1%) | 20 (57.1%) | 0.001 |
| | Grade 3 | 5 | 1 | |
| | Grade 4 | 0 | 0 | |
| Clinical assessment | Anterior tongue tie | 2 | 0 | |
| | Posterior tongue tie | 32 (72.7%) | 15 (42.9%) | |
| | without tongue tie | 10 (22.7%) | 20 (57.1%) | 0.005 |

Values are presented as numbers and proportions. Kotlow free tongue measurement: Normal, more than 16mm; Class 1, 12-16mm; Class 2, 8-11mm; Class 3, 3-7mm; Class 4, less than 3mm. TRMR, Tongue range of motion ratio: Grade 1, more than 80%; Grade 2, 50-80%; Grade 3, 25-50%; Grade 4, less than 25%. The Fisher's exact probability test was performed to assess the difference of proportion between two groups.

To assess the association between the clinical assessment of posterior tongue tie and the TRMR grade, the percentage of each grade between all patients who had posterior tongue tie was calculated (Table II). An overwhelming majority (85.1%) of patients diagnosed with posterior tongue tie clinically scored TRMR grade 2 (mild tongue restriction), and some (8.5%) scored TRMR grade 3 (moderate tongue restriction). Only 6.4% of patients diagnosed with posterior tongue tie scored TRMR grade 1 (normal tongue mobility).

## Discussion

The tongue tie diagnostic criteria have remained equivocal between previous studies,[18,20] with a prevalence ranging from 4% to 10%.[1,5,21] Using the Kotlow classification,[17] which was often previously applied,[4,11,19,22] the distance of the insertion of the lingual frenum to the tip of the tongue is measured, and a length of more than 16 mm is considered normal (without tongue tie). From the present results, greater than 75% of the patients in both groups were diagnosed as normal by the Kotlow classification, indicating that neither group had anterior tongue restriction. However, 72.7% of patients in the MSE group and 42.9% of patients in the control group were diagnosed with a posterior tongue tie by the clinical examination. In addition, in comparison with the data reported in past studies,[1,5,21] a significantly high prevalence of posterior tongue tie was observed in both the MSE and control groups in the present study. Posterior tongue tie is considered when the lingual frenum is short, thick and tied at the bottom of the tongue by a posterior submucosal attachment.[7] Therefore, diagnosing posterior tongue tie by the Kotlow classification alone seems inexact.

Recently, clinicians have focused on the limitation of tongue mobility to diagnose tongue tie.[19] In the present study, posterior tongue tie was evaluated using the TRMR and a clinical examination in order to assess whether there was a correlation between the two diagnostic methods. The current study showed that the number of patients identified with a posterior tongue tie was 85.1% in TRMR grade 2 and 8.5% in TRMR grade 3, indicating a high correlation between the clinical finding of posterior tongue tie and tongue restriction based on the TRMR. However, 6.4% of patients diagnosed with a posterior tongue tie revealed a TRMR of grade 1.

Table II. Correlation between the TRMR grade and clinical finding within patients with posterior tongue-tie.

| | | Posterior tongue-tie ($n$ = 47) | |
|---|---|---|---|
| | | Subjects | Proportion(%) |
| TRMR grade | Grade 1 | 3 | 6.4 |
| | Grade 2 | 40 | 85.1 |
| | Grade 3 | 4 | 8.5 |
| | Grade 4 | 0 | 0.0 |

TRMR, Tongue range of motion ratio: Grade 1, more than 80%; Grade 2, 50-80%; Grade 3, 25-50%; Grade 4, less than 25%.

In patients with restricted jaw opening for various reasons (short range of motion, tight muscles, temporomandibular joint complication), MIO becomes smaller, and TRMR subsequently is overestimated. The TRMR grade can be affected by a patient's capacity to open their mouth and tongue restriction can be under-diagnosed in this circumstance. Accordingly, there is a risk of misdiagnosing a posterior tongue tie when using only TRMR for assessment. Furthermore, the patients presenting with a posterior tongue tie can force a greater elevation of the tongue beyond its restriction level by raising the oral floor, which inflates the MOTTIP value and causes an overestimation of TRMR. Similar to cases of jaw restriction, a forced tongue elevation could present difficulties in measuring the severity of tongue restriction and immobility. The small percentages of patients in TRMR grade 3 and grade 4 may be underestimated if a significant number of patients had either a relatively small maximum opening and/or an ability to force-elevate their tongue.

Therefore, in the present study, the clinical examiner passively held down the oral floor during the tongue elevation exercise, which prevented forced elevation and exposed the position of the posterior tongue tie. This method can overcome the inherent problems associated with the TRMR measurements in individuals with restricted jaw motion and/or an ability to force-elevate the tongue. It is essential to assess a posterior tongue tie by a clinical examination, which can overcome the shortcomings of the Kotlow classification and the TRMR measurement system. The intra-examiner error evaluation indicated that this method was easy-to-perform and reliable.

Nevertheless, the MSE group still had a significantly higher level of TRMR grade 2 than that of the control group (MSE group, 81.1%; control group, 57.7%), although the extent of the tongue tie may have been underestimated. In addition, the clinical examination revealed that the posterior tongue tie was significantly more prevalent in the MSE group than in the control group (72.7% and 42.9%, respectively). The results indicated that the patients with a maxillary deficiency had restricted tongue mobility compared with patients without a transverse discrepancy. The transverse discrepancy between the upper and lower dental-arches/basal-bones is routinely evaluated by a clinical examination and cone beam computed tomography, and only those with a significant transverse discrepancy beyond the limit of orthodontic compensation were offered maxillary skeletal expansion. It could therefore be concluded that the subjects in the MSE group had a severe transverse skeletal discrepancy.

Previous reports have described a high correlation between tongue tie and a narrow maxilla.[11,12] However, those studies assessed the association of a tongue tie separately between the maxillary and mandibular width. When making a decision about orthodontic maxillary expansion, not only the maxillary width but also the transverse relationship between the two jaws requires assessment. Therefore, the association between tongue tie and transverse relationship was compared in the present study. The results indicated that there was a significant association between posterior tongue tie and a severe transverse skeletal discrepancy which suggests that the posterior tongue tie may have contributed to the development of a skeletally narrow maxilla.

### *Study limitations*

Several limitations associated with the present study warrant consideration. This was a retrospective study and the prevalence of a posterior tongue tie was compared between subjects with and without a transverse maxillary deficiency. The cause and effect relationship between a maxillary transverse problem and a tongue tie is not definitive, and more direct prospective longitudinal studies exploring the relationship are indicated. As a future study, the identification of other possible compounding factors associated with a narrow maxilla and posterior tongue tie are needed in order to further understand the interrelationship of multiple factors that may be involved in the development of maxillary transverse deficiency. Furthermore, the MSE group had more class 3 patients, and the control group had more class 2 patients. A future study should include the

association between a tongue tie and the antero-posterior (AP) relationship. If a posterior tongue tie can be proven to be a major influence in the development of maxillary deficiency, a sublingual frenectomy in the early stage of development may be considered as a preventive measure.

## Conclusions

To diagnose posterior tongue tie appropriately, a clinical examination and numerical assessments were applied in the present study. The results indicated that the clinical assessment was simple and accurate, whereas a numerical assessment alone appeared to be difficult to accurately diagnose a posterior tongue tie. Patients with a transverse discrepancy and a severely narrowed maxilla requiring skeletal expansion showed a significantly higher level of posterior tongue tie and restricted tongue mobility compared with patients without a maxillary deficiency. A posterior tongue tie seems to have a high association and correlation with a severe transverse deficiency. Its exact role in the transverse discrepancy and causal relationship requires further investigation. Understanding the role of a posterior tongue tie in patients who require skeletal expansion may help in the diagnosis, planning, prevention, treatment and retention of these complex problems.

## Conflict of Interest

The authors declare that there is no conflict of interest.

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## Acknowledgements

I would like to thank B. Quinn, Japan Medical Communication, Japan, for carefully proofreading the manuscript.

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