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Preliminary radiographic observations of the tongue-repositioning manoeuvre

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SUMMARY The tongue-repositioning manoeuvre (TRM) is a method to place the tongue in direct contact with the hard palate. The TRM makes use of voluntary generation of negative interocclusal pressure controlled by an intra–extraoral pressure indicator device in combination with an oral shield. The aim of the study was to investigate whether the TRM influences vertical tongue position and/or tongue–velum contact.

Ninety consecutive patients (75 males, aged 26–76 years, and 15 females, aged 36–70 years) who presented with snoring and/or obstructive sleep apnoea (OSA) were examined at the University of Göttingen. Two cephalograms, with and without the TRM, were taken and traced. The data were analysed using Wilcoxon matched-pairs signed-rank test.

Evaluation of the TRM demonstrated a significant increase ($P < 0.01$) of the mean tongue–velum contact from 6.3 to 24.5 mm and a significant decrease ($P < 0.01$) of the mean tongue–palate distance (12.3–3.1 mm) measured perpendicular to the nasal line. This was compatible with an intensification of posterior mouth closure and a contact position of the tongue with the palate.

Introduction

The position of the tongue in the oral cavity has a significant impact on orthodontic therapy, myofunctional disturbances, as well as on diagnosis and therapy of snoring and obstructive sleep apnoea (OSA).

There is evidence that assistance in mouth closure and the resulting tongue position may reduce the symptoms of snoring (Campion, 1985; Veres, 1993). This requires a rest position of the tongue, after swallowing, in direct contact with the hard and soft palate, which has been described and analysed by various authors using different objective methods.

Eckert-Möbius (1953) examined the tongue on lateral cephalometric radiographs under diverse functional conditions, including the Körbitz (1914) manoeuvre. This was confirmed by Wein *et al.* (1988), who analysed the tongue position with sonography. They noticed a congruent shape of the tongue dorsum consistent with a close palate–tongue contact at the end of the oral phase of deglutition. Engelke *et al.* (1995), who examined velar and lingual movements during swallowing with electromagnetic articulography, observed after velopharyngeal swallowing activity, an immediate contact position of the tongue with the hard palate in conjunction with an antero-inferior uvula position, which also confirmed the observation of Eckert-Möbius (1953). At the same time, these findings provided evidence of the formation of a velolingual seal after deglutition which contributes to the stabilization of the tongue in the oral cavity.

Observation of orofacial functions with polysensography by Engelke and Hoch (1999) revealed a cranial tongue position after swallowing. The interactions between respiration and the swallowing of solid food were described by Palmer and Hiiemae (2003) based on videofluorography and electromyography. They observed an extended plateau in nasal air pressure when bolus aggregation in the valleculae took place.

Fränkel (1967) reported on the dynamics of interocclusal negative pressure and stated that 'If the cheeks, lips, and tongue are covered with acrylic shields to impede an interocclusal position, a subject is unable to open his mouth after swallowing due to interocclusal negative pressure'. That author also revealed the formation of an inner closure of the oral cavity by a contact of the velum with the tongue dorsum.

Engelke (2003) described a tongue-repositioning manoeuvre (TRM), based on the proposals of Körbitz (1914) and Fränkel (1967), to keep the tongue in a contact position with the hard palate after deglutition. Using interocclusal negative pressure as a biosignal to detect the formation of both the anterior and posterior seal of the oral cavity, the patient can be instructed to maintain the contact position of the tongue and the palate. Tongue repositioning can be controlled using a membrane funnel shield (MFS; Figure 1). The funnel, covered by a membrane, serves as a simple measuring device according to the principle of communicating tubes. The membrane displays extraorally

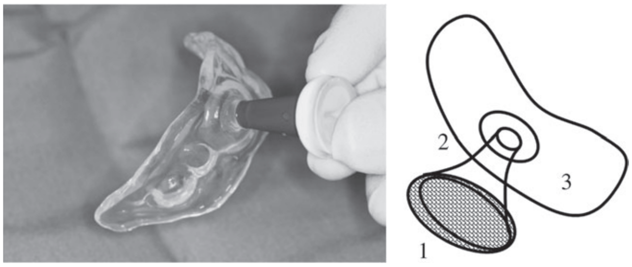

Figure 1 Membrane funnel shield. 1, Membrane; 2, Funnel; 3, Shield.

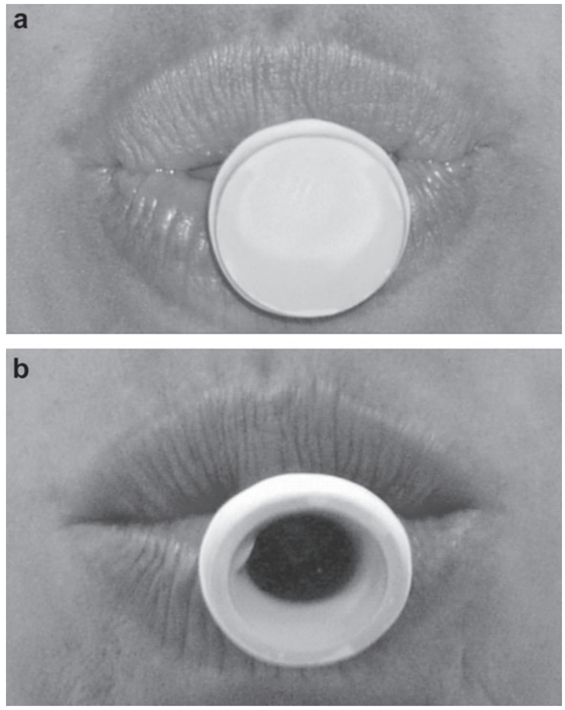

Figure 2 Pressure control during the tongue-repositioning manoeuvre. The membrane funnel shield (a) during intraoral atmospheric pressure and (b) indicating strong negative interocclusal pressure (greater than 150 Mbar).

the pressure in the interocclusal space and permits, in particular, application of negative pressures as a biosignal for diagnostic and training purposes (Figure 2b).

The aim of the present study was to evaluate the clinical performance of the pressure-controlled TRM. Based on the hypothesis of the study, that during swallowing the orofacial unit represents a closed hydraulic system, maintenance of the negative interocclusal pressure (IOP) after swallowing should result in formation of a posterior oropharyngeal seal and palate–tongue contact due to an evacuation of the oral cavity (Figure 3b).

Using lateral radiographs, the study aimed to answer the following questions:

1. Does the TRM influence the vertical tongue position?
2. Does the TRM influence the tongue–velum contact?

Subjects and methods

Ninety consecutive patients (75 males, aged 26–76 years, and 15 females, aged 36–70 years) referred to the Department of Oral Surgery of the Georg-August-University Göttingen. All presented with snoring problems and/or OSA, and were examined to identify the sites of obstruction, to analyse spontaneous tongue position, and to verify the change of tongue position during the TRM. Thirteen subjects were excluded from the initial sample for the following reasons: inadequate performance of the TRM (pressure change during the 10-second period), inclined body position, deviant jaw position, or technical errors in at least one of the cephalograms.

All patients underwent anamnestic and clinical evaluation according to a standardized protocol (Engelke, 2003). The examination comprised a clinical oral and nasal inspection with reference to oropharyngeal anatomy and nasal airway anomalies. A functional examination was carried out to evaluate voluntary snoring loudness, the type of respiration, and orofacial habitual anomalies. The dental examination included impressions and fabrication of study casts. Examination of breathing mode made use of the MFS. If alternating pressure synchronously with respiratory activity was detected, internal mouth breathing was confirmed.

Assessment of IOP

For clinical assessment of IOP, a MFS (Figure 1) was used. The device, which consisted of a custom-made thermoplastic vestibular shield to allow individual adaptation before use, ended at the molar region bilaterally to provide complete obturation of the lips. A funnel was integrated in the centre, with the outer orifice covered by a disposable latex membrane. The inner orifice of the funnel was directed towards the dental arch and thus communicated with the interocclusal space. Changes of pressure in the interocclusal space resulted in variable membrane movement: externally directed movement indicated positive pressure, inwardly directed movement negative IOP. Maximal inward movement (Figure 2b) of the membrane was taken as the clinical criteria for formation of sufficient negative IOP (greater than 150 mbar).

Radiographic examination

A lateral cephalogram (left to right view) was obtained (X-ray unit Orthophos-C, Siemens, Bensheim, Germany) while the patient was seated in an upright position. The patient's head was positioned with the Frankfort horizontal plane parallel to the central beam during exposure. The exposure time was 0.40–0.50 seconds. Tube voltage varied between 73 and 80 kV and tube current from 14 to 15 mA. The dorsum of the tongue was coated with Microtrast oesophageal

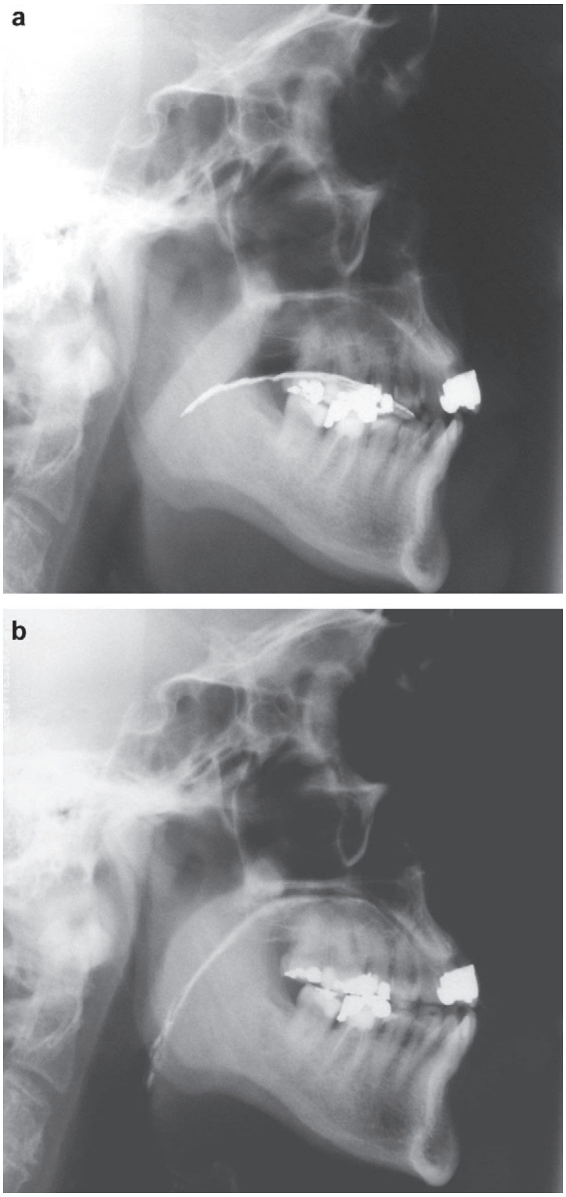

Figure 3 Lateral cephalograms showing spontaneous tongue and velum position (a) and elevated tongue position and increased tongue–velum contact during the tongue-repositioning manoeuvre (b).

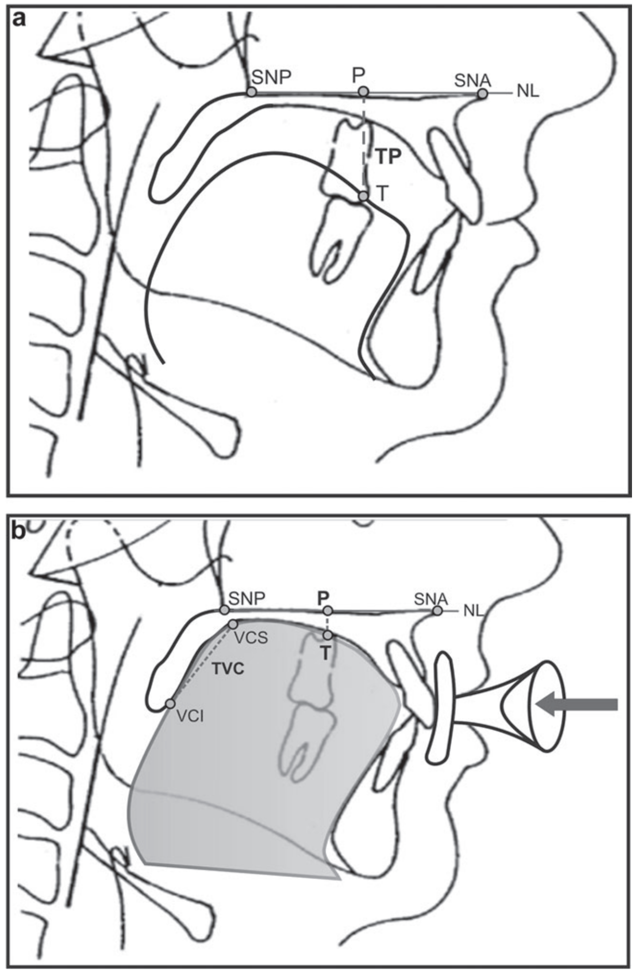

Figure 4 Schematic diagram of the tongue-repositioning manoeuvre (TRM) with landmarks for radiographic evaluation. SNA, anterior nasal spine; SNP, posterior nasal spine; NL, nasal line; P, palate point, centre of the nasal line; T, tongue dorsum point on a line perpendicular to NL through P; VCS, superior contact point of velum and tongue; VCI, inferior contact point of velum and tongue; TD, distance of tongue dorsum (T) and palate point (P); TVC, distance VCS to VCI, linguovelar seal length. (a) Resting tongue position and (b) tongue position during TRM.

cream (Nicholas Laboratories Ltd, Slough, Berkshire, UK) in order to facilitate identification of the dorsum at the tongue.

All patients underwent two radiographic examinations:

1. The first (Figure 3a) was taken without special instructions to the seated subjects with the jaws closed, the lips in light contact, and natural head position in order to obtain a habitual spontaneous tongue position. No information was given concerning TRM.
2. The second (Figure 3b) was taken in an identical head position with an MFS placed in the vestibulum. The patients were requested to 'collect their saliva' and to swallow repetitively to generate as much negative pressure as possible. Full inversion of the membrane represented more than 150 Mbars. After obtaining full inversion of the membrane into the funnel, they were instructed to breathe normally through the nose maintaining the negative pressure for at least 10 seconds. The radiograph was taken at count 5 of 10 seconds during the period of negative IOP (Figure 3b).

For analysis of the cephalometric radiographs, the landmarks shown in Figure 4 were used.

The resting (Figure 4a) and a tongue position during the TRM (Figure 4b) are displayed schematically including all landmarks. All radiographs were traced over a 2-week period by one author (MM) with an accuracy of 0.5 mm.

Results

Vertical tongue position

The tongue–palate distance (P-T) showed a mean value of 12.3 mm [range 1–23, standard deviation (SD) 5.85] during spontaneous tongue positioning. The mean value changed to 3.1 mm (range 1–20, SD 3.55) during the TRM (Figure 5). Comparison of the data using Wilcoxon matched-pairs signed-rank test revealed a significant reduction of P-T when performing the TRM ($P < 0.01$).

Tongue–velum contact

Tongue–velum contact in the spontaneous position, represented as VCS (superior)–VCI (inferior), showed a mean value of 6.28 mm (range 0–28, SD 7.44). During TRM (Figure 6), the mean value increased to 24.5 mm (range 0–43, SD 8.12). Comparison of both conditions revealed a significant difference [Wilcoxon matched-pairs signed-rank test ($P < 0.01$)].

Consequently, there was a considerable increase of the tongue dorsum palate contact compatible with the hypothesis of the formation of a posterior linguovelar seal and reduction of free intraoral space.

For 50 per cent of the cephalograms under spontaneous tongue position, no tongue dorsum palate contact was visible; however, during the execution of the TRM, the velum and the tongue showed, in all but one subject, a contact zone.

Discussion

According to Eckert-Möbius (1953), if a subject is examined without previous instruction, the dorsum of the tongue in the oral cavity is projected in variable unpredictable positions and cannot be placed in standardized manner. That author used the manoeuvre of Körbitz (1914) to place the tongue in a palatal contact position, but no statistical data were provided.

The results of the present study clearly reveal that using negative pressure in the interocclusal space as a biosignal, the position of the tongue is significantly changed from a distant variable position towards the hard palate. However, a complete contact of the midsagittal contour of the tongue and the hard palate was not visible in all subjects. This is primarily due to the variable palatal mucosa thickness which has to be subtracted from the measured P-T distance. Furthermore, it may be caused by insufficient performance of the TRM with the tongue tip occluding the funnel orifice in an anterior open bite situation or, more frequently, by incomplete evacuation of the oral cavity during swallowing. Nevertheless, in most of the subjects, negative intraoral pressure leads to a narrowing of the tongue and the hard palate consistent with a direct surface contact of both structures.

There is a lack of information concerning the three-dimensional (3D) configuration of the tongue in the oral cavity. The present study only provides data of the midsagittal contrast with barium sulphate and therefore needs to be confirmed by measurement with 3D tomographic techniques in further studies.

When measuring pressures inside the oral cavity (Christiansen *et al.*, 1979; Halazonetis *et al.*, 1994; Thüer *et al.*, 1999; Kucukkeles and Ceyanoglu, 2003), it is important to define the measuring site and the measuring conditions to allow correct interpretation of the data. In this study, intraluminar pressure was assessed in the interocclusal space of Fränkel. This compartment which interconnects the interdental and interocclusal spaces formed by the teeth allows free communication of air and/or liquid along the dental arch. It is sealed vestibularly by the buccal soft tissues and orally by the tongue. The space of Fränkel is temporarily connected with the space below the palatal vault if the tongue is lowered. However, measurement of atmospheric pressure in the palatal vault (Thüer *et al.*, 1999) and in the interocclusal compartment has to be differentiated. Narrowing of the tongue to the palate separates both spaces; therefore, negative pressure may be independently present in one of the compartments. Iida

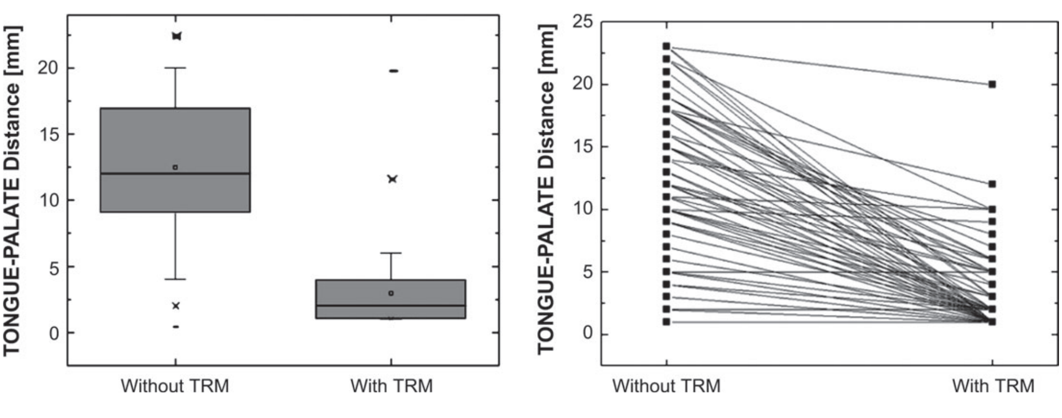

Figure 5 The influence of the tongue-repositioning manoeuvre (TRM). The box plot (left) and linear diagram (right) show the reduction in the tongue–palate distance.

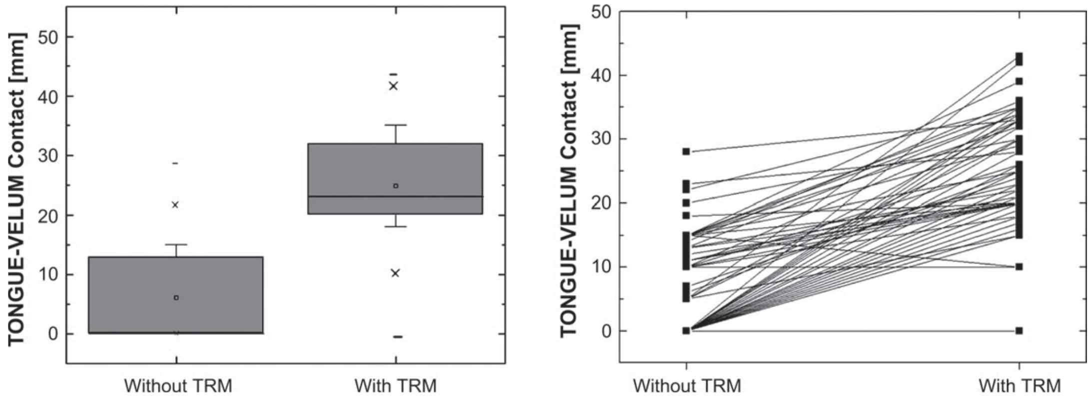

Figure 6 The influence of the tongue-repositioning manoeuvre (TRM). The box plot (left) and linear diagram (right) demonstrate the increase in tongue–velum contact.

et al. (2003) who investigated velar movements in subjects with deglutition disorders observed negative intraoral pressures during sucking. The measurement site inside the oral cavity communicates with the interocclusal compartment during sucking and therefore may be compared with the findings in the present study. Iida *et al.* (2003) also observed, videofluoroscopically, a tight oropharyngeal closure during formation of negative intraoral pressure when sucking water. The present findings are in agreement, where an increase in the length of the velolingual contact zone was observed during the TRM. However, there is evidence that remaining negative pressure is present in pauses between sucking activity of 5-day-old infants (Lindner and Hellsing, 1991) which, according to the authors, is probably due to closure of the oral cavity posteriorly by the tongue.

The present investigation demonstrated that the TRM leads to a substantial change of tongue position in the oral cavity. The 'tongue parking position' (Engelke, 2003) close to the palate was confirmed. Therefore, maintenance control of negative pressure in the interocclusal compartment, as a possible therapeutic measure for snoring, leads, at least during the period of radiographic diagnosis, to an intensification of the oropharyngeal seal and to a narrowing of the tongue towards the hard palate. There is also evidence that negative IOP persists during sleep for longer periods when using vestibular shields (Witt and Kühr, 1969). This may explain the reduction of snoring observed with vestibular shield treatment (Veres, 1993).

It should be stressed that the function of the oral cavity as a closed hydraulic system (Fränkel, 1967; Lindner and Hellsing, 1991; Engelke, 2003) also has an impact on the upper airway. A closed hydraulic system does not require any muscle activity to maintain its stability and therefore may contribute to the stabilization of the anterior pharynx wall during sleep. It has been suggested that predominantly mechanical rather than neuromuscular factors modulate the properties of the pharynx after abrupt reductions in nasal pressure (Schwartz *et al.*, 1998). For changing the mechanical conditions, swallowing may play an important role. Following each deglutition, evacuation of the oral cavity takes place, resulting in closure of the oropharyngeal and labial seal (Engelke and Hoch, 1999). This serves to stabilize the midpharyngeal 'collapsable' segment holding the tongue and the velum in a contact position to the hard palate based on a 'vacuum mattress mechanism'. Examination of sucking activity of newborns (Lindner and Hellsing, 1991) indicated that during pauses in sucking activity, oropharyngeal closure and negative intraoral pressure persist. The persistance of negative pressure in the oral cavity may therefore play an important role in mechanical stabilization of the pharynx. Thus, the physiological position achieved by the TRM may also be an alternative in the treatment of patients, where protrusive devices are used to open the pharynx during OSA.

Conclusion

The TRM seems to be a suitable method to place the tongue in a therapeutically desirable position close to the hard palate and to intensify posterior mouth closure.

This may be of importance for various types of functional treatments of orofacial dysfunction such as snoring, OSA, open mouth posture, and tongue habits in adults and children, where mouth closure and stabilization of oropharyngeal soft tissues are required.

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