Laboratorial Study for Determination of Tongue Position in Lateral Cephalometric Radiograph Using a Barium Sulfate Paste for Radiographic Medium Contrast

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Abstract

Aims and Objectives: Due to the importance of relating radiographically the position of the tongue with structures of the buccal cavity, and its relation with the skull.

Objective: The purpose of this study was to verify the effectiveness of a radiographic contrast paste based on barium sulfate.

Method: Radiographs were obtained: skull macerated, tongue of pig, 5 ml syringe containing the paste, needle for spinal anesthesia. The lateral teleradiographies were obtained with variation of the factors and alteration of the position of the tongue.

Results: Radiographically, the pulp showed to be effective even when increased kVp and mA factors were used and it was possible to observe and determine the different positions of the tongue.

Conclusion: Within the laboratory conditions, the barium sulphate pulp presented adequate radiopacity, adequate viscosity, easy dispensing, compatibility with the lingual tissue and low cost.

Keywords: Barium Sulphate Paste; Buccal Cavity; Radiographic Contrast

Introduction

The tongue is formed essentially of skeletal muscle, being strong muscle, can cause deformities in the oral cavity. A radiographic examination is indicated, but it is not very efficient since the lingual apex is difficult to visualize. The lingual apex does not present an evident radiographic image, hindering or impeding the radiographic evaluation of the lingual position. To obtain a satisfactory image of the tongue, it is necessary to use a substance called contrast. Thus, we can better verify the position of the tongue through the X-ray and we must also associate complementary tests in order to obtain a more accurate diagnosis on the position and size of the tongue, which may be associated with disorders such as Obstructive Sleep Apnea Syndrome, check if the individual is a mouth breather, if he/she has atypical swallowing, check if the position of the teeth are being influenced by this organ or if the individual presents changes in phonetics [1]. Contrast is an available and essential feature to verify the lingual position, especially its apex, which can hardly be observed in frontal and lateral cephalograms [1].

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In the international market there are radiopaque substances that help to visualize the position of the tongue in the radiographs, but because they are difficult to acquire, high price, dispensing inadequate for individuals, they become unviable for use in radiology clinics in Brazil. Radiographic contrasts based on iodine and barium sulfate are substances used for this purpose. Barium sulphate in addition to providing good contrast does not have the drawback of producing the allergic reactions that some patients may present to the iodine based compounds.

Literature Review

The influence of the tongue on the oral cavity was studied by Brader [1]. The author considered that the shape of the dental arch is determined by the teeth and also by the opposition of the forces of the tongue and oral tissues. Resting tissue forces are the main determinants of the arch’s morphology, in contrast to the intermittent forces of the muscles in function.

Proffit [2] reports the factors that influence dental position, demonstrating the relationship between craniofacial angulation, that is, the way the head relates to the neck. He found that facial proportions, dento-alveolar proportions and posture of the head forward are strongly correlated with the occlusal plane. One of the primary factors of dental balance is linked to several forces (extrinsic, dental occlusion and the forces created from the periodontal membrane correlated with the force of dental eruption) and the resting pressure of the lip and tongue. It concluded that patients with flaws in the mechanism of dental eruption are more clinically important in order to study than previously believed.

According to Van Der Linden [3], the resting posture of the lips and tongue influences the shape of the dental arches and facial morphology during the growth phase of the face. Silva Neto [4], in his work on swallowing, considered that for more detailed observation of the process, resources such as radiography, cinefluoroscopy and video fluoroscopy have been used.

Cephalometric analyzes of tongue position

Natali, Polacco [5] compared the surface value of the tongue and malocclusions taking age and sex into account. Teleradiographies were traced and the measurements were statistically analyzed by analysis of variance, correlation coefficient, covariance in relation to age and analysis of variance with two controlled factors. They used the Brulin tracing to delimit the lingual surface starting from the anteroposterior angle of the hyoid bone body following the lingual insertion; rising towards the upper dorsal limit of the tongue to the apex; then going down to the apophysis geni and a segment from there to the starting point. They concluded that the average surfaces of the tongue are larger in the cases of classes II division 1 contrary to the established that the largest languages would be in individuals with class III; doubting the performance of glossectomy in class III patients and that the symptomatic difference between class II division 2 and class III would be more due to the lingual posture and the vertebral posture than to the quantitative appearance of their lingual surfaces.

Rocabado [6,7] developed a cranio-cervical biomechanical analysis with lateral teleradiography. The following aspects were studied [8]: (a) angular relationship of the skull and cervical spine; (b) distance between the base of the occipital bone and the posterior arch of the first cervical vertebra (Atlas) and its association with craniofacial pain; (c) position of the hyoid bone in determining the physiological curvatures of the cervical spine; (d) cervico-hyoid relationship and tongue resting position; (e) upper airway area column.

Strelzow, et al. [9] in the research work, used 90 white men, diagnosed with obstructive sleep apnea. Teleradiographies were obtained with the patients seated. Each patient was instructed to fix their gaze on the horizon, so that their habitual occlusion could be reproduced, their lips sealed and their tongue on the oral floor. The cephalometric exams allowed to obtain the indexes that were correlated with the obstruction of the air space. This study indicated that in less than 50% of cases, cephalometric measurements were significantly different in patients with obstructive sleep apnea. The authors demonstrated the importance of cephalometric tests due to the correlation between soft and hard tissues, taking into account the performance of these tests for successful surgical treatment.

DeBerry-Boroweicki, et al. [10] cephalometrically studied obstructive sleep apnea in 30 adult patients (27 men and 3 women) aged 42 to 52 years and in 12 control patients (10 men and 2 women). They concluded that patients with apnea have a wider tongue than the control group, the hyoid bone was located more inferiorly, the mandible is normal in size and position, but the maxilla is retropositioned and the elongated hard palate, the oropharyngeal and hypopharyngeal space are reduced by up to 25%, a factor that can be caused by obstructive sleep apnea. Cephalometry proved to be important in the diagnosis and clinical investigation of patients with suspected obstructive sleep apnea and should be used as a routine examination together with a clinical analysis of the head and neck, with polysomnography and endoscopy.

Schwab, et al. [11] studied the upper airways with respect to the geometry and caliber of the airways, in 21 patients classified by polysomnography as normal individuals, in 21 individuals who snored and had medium-grade apnea and 26 patients with obstructive sleep apnea. The traces were performed on images obtained by magnetic resonance. The measurements considered in the tracings quantified the size of the lateral pharyngeal walls and the parapharyngeal fat mattress, axially and sagittally, to verify how much they compromised the upper airways. The sagittal soft structures studied included anteroposterior width of the soft palate; oblique width of the soft palate; length of the soft palate; length of the central line of the soft palate; soft palate area; antero-posterior width of the tongue; oblique tongue width; distance between the mandible and the soft palate; distance between the mandible and the posterior pharyngeal wall and the tongue area. After statistical analysis, they concluded that the reduction of the airways in apneic patients occurred predominantly due to the narrowing in the lateral direction and that instead of the increase in the parapharyngeal fat mattress, the anatomical factors are the cause of the narrowing of the airways.

Aras [12] stated that for the stomatognathic system, a multiple assessment of chewing, swallowing, breathing, phonation, posture and status, of each component involved in the performance of functional activity is necessary. Thus, part of the functional analysis must involve cephalometry and dental measurements based on study models and other instruments. Devices that directly influence the muscles of the lips and face also have an indirect influence on the position of the tongue. The position of the tongue at rest depends on and changes with, the position of the head. The functional examination to check for dysfunctional aspects requires assessment of the tongue, lips, cheeks and hyoid muscles. The first steps to be taken for the exam are clinical observation and functional tests, supported by cephalometric analyzes. In examining the tongue, as already indicated, not only function, but also posture, size and shape of the tongue are significant. Some researchers maintain that the language posture is more important than the function [2]. The tongue posture is examined clinically with the mandible in a postural resting position. A sagittal cephalometric record of this relationship is also indicated. The cephalometric analysis is accurate, reproducible and simple, it can be used in the private clinic. The use of radiopaque contrast (such as barium paste) on the tongue allows visualization during palatography.

Use of barium as a substance for radiographic contrast

Huston Jr Cunningham [13] studied whether there is a risk of barium sulfate entering the lungs when the pharynx and esophagus exams used the radiographic contrast medium. The contrast was introduced by tracheal intubation in 18 rats, which were sacrificed at intervals of 2, 12, 48 and 72 hours and 7, 15, 30, 94 and 126 days. The lungs were removed and analyzed microscopically. They concluded that there was a mild inflammatory reaction, but that the substance barium sulfate is relatively inert in the lungs of rats.

Frech, et al. [14] in a research using 8 dogs and 20 rats, compared the effects of rapid injection of 2 ml of iodine-based contrast (Hypaque 40%) and barium sulfate-based contrast (Barosperse) in the trachea through a vascular catheter and radiographs were performed. All dogs survived, except one that developed pneumothorax. They have thus shown that the use of barium sulfate as a means of radiographic contrast in dog windpipes causes less edema than the injection of iodinated compounds. They did not indicate any clinical preference between the 2 compounds, but noted that although the substance based on barium sulfate is more viscous and more difficult to eliminate it does not evoke as much fluid outflow as Hypaque.
Dodd,. et al. [15] discussed the most appropriate contrast medium in cases of suspected esophageal interruption. They considered the adverse effects of different contrast media, whether there was a more appropriate contrast agent for a given clinical situation and whether there was a line of reasoning that could be applied to all circumstances. They considered the iodinated contrast media diluted in water; but that before there should be a question about the possible allergic problems. Barium sulfate within the lumen of the gastrointestinal tract is inert and has no adverse effect, unless proximal thickening of an obstructive lesion of the left colon. They observed that when in contact with the trachea region, barium compounds are less irritating and cause less injury than iodinated compounds. Thus, barium sulfate is the substance of choice for exams to search for fistulas and esophageal perforations.

Although iodine-based and water-soluble compounds are recommended for gastrointestinal perforations, Foley,. et al. [16] studied the use of a barium sulfate-based substance. The study was carried out clinically in 5 men and 1 woman between the ages of 22 and 67 years and laboratory in radiographs of two polyethylene tubes with diameters of 1.5 mm, one with 50% barium sulfate suspension and the other with Gastrografin (37% iodine), placed in phantom. The radiographs were obtained with 90, 100, 110 and 120 kVp and 200 mA. Clinically, barium sulfate accurately showed the location and extent of the perforations, which were not observed with the iodized medium. Experimentally, barium sulfate showed greater visibility than that of iodinated compounds, in all four exposures. In patients, gastrointestinal contrast barium sulfate was efficient in showing defects where the iodinated compound had failed.

Haruki,. et al. [17] studied the relationship between oral morphology and tongue habits in 83 patients (31 men and 52 women) with an average age of 9 years and 1 month, diagnosed with an unfavorable tongue and lip posture, harmful oral habits and 65 patients formed the control group. They made tracings in teleradiographies and photographs of the face in the frontal and lateral views. Radiographic shots were taken after the use of barium sulfate and the patient swallowed, since after this act the tongue assumes the resting position. They studied the relationship between the shape of the tongue, posture and lips related to the axial position of the incisors. They concluded that patients with oral habits have lower overjet and overbyte than those in the control group, the tongue is located more inferiorly when at rest, the angle of the jaw (AMF) is greater in patients with habits and that the natural eruption of teeth is correlated with the opposition of forces between tongue and lips.

Marc,. et al. [18] based on the review of articles on the use of barium sulfate as a contrast agent, found that the substance can cause irritation when in contact with the peritoneal cavity in esophagograms. They found in the literature that iodine-based contrasts are the most indicated in postoperative esophageal perforations, but when aspirated these iodine compounds can cause pulmonary edema. The diluted barium sulfate (50%) is indicated for the detection of esophageal perforations with precision. The disadvantage of using contrast dissolved in water is the reduction in radiopacity when compared to barium sulfate without dilution. Iodine can cause allergic reactions in allergic patients. The authors showed themselves to be in an opposite position to the use of iodine compounds and were favorable to the use of barium sulfate, which is inert and safe when present in the tracheobronchial tree.

**Contrast substance to assess tongue position**

Milne IM and Cleall JF [19] studied oropharyngeal physiology by cinefluorographic radiography in groups of male students and three groups of adolescents of both genders, with normal occlusion, Class II and projection of the tongue. They used cinefluorography and as a contrast substance, tantalum oxide in orabase in the midline of the tongue and lips. They concluded that although the oropharyngeal movements are relatively constant in the same individual, they varied considerably between different individuals; relative perpendicularity between the Frankfurt Horizontal Plan and the true vertical; no conclusive differences were observed between the groups and that during swallowing the normal group showed little head extension, in the Class II group the extension was observed for a longer time and in the group with tongue projection the head extension preceded by flexion.

Guay,. et al. [20] studied patients with severe Class III malocclusions radiographically to determine the language posture during rest and phonation of /s/, their speech and hearing were also assessed, all individuals had normal hearing, 11 of whom were from a group of

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12 individuals had some degree of change in the wheezing of the phoneme /s/, the tongue, probably the most functionally active part of the oropharyngeal system is directly influenced by changes: oral-dental, environmental, especially the mandible. They observed that the tongues are wide, in most cases with posterior crossbite, but on cephalometric radiographs they did not appear to be wide, to fit completely in the oral cavity.

Lowe, et al. [21] carried out a study on dento-skeletal analysis in soft tissues, correlated tongue, a cephalometric analysis in the resting position. They observed the relationship between dento-skeletal and soft tissue variables in 60 adult women with anterior open bite and normal occlusion and through lateral radiographic shots with the patient at rest with the aid of radiopaque substance. The authors concluded that in individuals with skeletal anterior open bite, the posture of the tongue is related to the position of the incisors.

Takada, et al. [22] studied the resting posture of the tongue, by electromyography to quantify the time interval, for the tongue to reach the standard resting value after swallowing and by cephalometry, the position of the tongue, hyoid bone and pharynx. Thirty skeletal Class I adult women were used in the sample, making up the control group, and 30 Skeletal Class I adult women with anterior open bite. For each group, 3 lateral teleradiographs were performed with the mandible at rest 10 seconds after swallowing, the time intervals were calculated with the aid of electromyography. They performed cephalometric tracings and analyzed them statistically. They observed that the group with an open bite had a higher tongue than the control group, however the tongue was not larger in size compared to the control group.

Ono., et al. [23] studied the interactions between upper airway structures and posture in relation to obesity and neck circumference in patients with obstructive sleep apnea. The study was carried out with 61 adult males, Class I, with obstructive sleep apnea (respiratory arrest for more than 10 seconds) and 10 men in the control group. The lateral cephalometric radiographic shots were performed both in an upright position (with natural head position) as well as in a lying position and radiographic contrast was used. The patient was asked to lie down, adjust the pillow in the sleeping position and the teeth should remain without contact as in the resting position. Radiographic shots were taken after 3 breaths followed by 3 breaths. They concluded that the morphological characteristics of craniofacial structures have a great influence on the function of the tongue and mandible muscles and vice versa. Statistics data were obtained from cephalometry. When the radiographs were taken with the patients lying down, there was a greater extension of the neck, movement of the hyoid bone in the anteroposterior direction and in conjunction with the more upward and forward rotation of the mandible.

Lowe., et al. [24] using cephalometry and polysomnography, studied 291 men with obstructive sleep apnea and 49 with snoring without apnea. The natural position of the head, which in apnea patients is usually extended and forward, was statistically analyzed. The statistical analysis used was that of the minimum partial square and concluded that the analysis of the position of the head has a correlation with the thickness of the neck, obesity and that certainly influence the measurements that are used to assess the severity of obstructive sleep apnea. In order for the lines of the tissues and upper airways to be visualized radiographically, patients were asked to swallow one of 1 spoon of radiopaque barium substance in the form of 65% cream so that the back of the tongue and upper airways were visible. The authors considered as functional balance factors: the intrinsic forces of the tongue and the lip, extrinsic forces and habits such as sucking, forces of dental occlusion and periodontal forces. He believes that the position of both the cheek and the tongue directly influence the dental position. Many observers believe that the balance is due to the opposition of forces of the tongue and lips, logically that in patients with incorrect swallowing they have protruding incisors and an open bite caused by the difference in pressure of the tongue and lips. There is a postural relationship between the head, jaw and tongue and they are closely related to certain influences and their responses.

Buecker, et al. [25] in a study of the location of esophageal perforations in 67 patients. They concluded that the structures are more visible with the use of barium sulfate than with contrast substances in the aqueous medium (based on iodine - Telebrix or Slutrast).

Tessitori [26] studied the usual position of the tongue, using the radiographic method, in individuals with different breathing patterns and different types of dental occlusion. It concludes that the placement of barium sulfate contrast on the tongue allows the visualization of

the apex and back of the tongue. The usual position of the tongue does not depend on the breathing pattern or the type of dental occlusion.

Kawamura, et al. [27] studied the movement of the tongue during swallowing through cineradiography and classified the swallowing process into 6 stages through the movement of the apex and back of the tongue. They observed that in patients with open bite, both the apex and the dorsum of the tongue are positioned more anteriorly and inferiorly and that starting from the resting position, they perform a shorter trajectory.

Aim of the Study

This work aims to verify in laboratory, the effectiveness of a paste based on barium sulfate as a radiographic contrast, to determine the position of the tongue, its changes in position in the oral cavity and its relations with the surrounding structures.

Materials and Methods

Because it is an experiment involving several exposures to ionizing radiation, a macerated skull mounted on a support was used to perform the radiographic shots. A cardboard support was placed near the base of the skull jaw to simulate the oral floor and support the pig tongue to be used in the experiment. The barium sulfate paste, to be tested, comes packed in a 5 ml syringe. To facilitate dispensing the paste on the surface of the tongue, a needle, used in spinal and epidural anesthesia, was attached to the syringe to facilitate dispensing. The pig’s tongue was placed in the space corresponding to that occupied by the tongue in the oral cavity (Figure 1 and 2).

Figure 1: Flowchart for the total study population.

Figure 2: Tongue positioned on the macerated skull.

To assist in the simulation of the various positions of the tongue, resources such as insertion of blocks of utility wax, dental floss and cotton were used to alter and maintain the tongue in position in the radiographic shots.

After obtaining the desired tongue position, the barium sulphate paste was dispensed in the central portion of the tongue in the lateral outlets (Figure 3 and 4) and in the lateral portions in the PA outlet. Due to its thick gauge, the needle allows the thick material to be dispensed without clogging problems and provides greater homogeneity to the paste line.

**Figure 3:** Pig tongue positioned with barium sulphate paste placed.

**Figure 4:** Skull positioned for lateral radiographic take.

First, lateral teleradiographies were obtained with changes in the factors to assess whether they interfered with the visualization of the contours of the tongue. Different factors were taken to see if their alteration could compromise the radiographic contrast (Figure 5-8). After taking shots varying the factors, the radiographs were obtained with the following factors: 60 kVp, 9 mA and 0.5 seconds of exposure in an Ortophos CD device (Siemens). The films manufactured by Kodak, measuring 18 x 24 cm, were processed in Kodak solutions. After drying, the radiographs were scanned and evaluated.

**Figure 5:** Exposure factors: exposure time - 1.2 seconds; kV - 60; mA - 12.

**Figure 6:** Exposure factors: exposure time - 1.2 seconds; kV - 66; mA - 16.
Regarding the different positions of the language and based on the literature, we try to simulate positions that it assumes during the functions of swallowing, phonation; chewing; as well as at rest considering physiological and altered positions.

We attempted to simulate the following positions: resting, lateral projection of the tongue, tip of the tongue touching lower incisors and elevated back, tip of the tongue lowered and elevated back, tip of the tongue touching the palate and lowered back, folded tongue

**Figure 7:** Exposure factors: exposure time - 1.2s; kVp – 77; mA - 14.

**Figure 8:** Exposure factors: exposure time - 1.2s; kVp – 71; mA - 15.

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forming a groove and lowered back, protruding tongue, tip of tongue touching lower incisors and lowered back, back in contact with hard/soft palate region.

Discussion

The importance of a morphological examination of the tongue and the relationship it maintains with the structures of the oral cavity lies in the fact that asymmetries are common and that although the alterations generally do not compromise aesthetics, they can cause functional problems. The assessment of the tongue must include data related to size, shape, as well as the posture it assumes while the jaw is in its postural position. According to Moss's functional theory for adequate craniofacial growth and development to occur, the oral cavity must have its spaces filled with subatmospheric pressure to promote growth and prevent atmospheric pressure from interfering with the functions of the stomatognathognatic system. Thanks to subatmospheric pressure, the tongue is kept juxtaposed to the palate [28].

In the literature, the interaction between volume, tongue position and facial morphology has been emphasized and consequently its relationship with the skull [1,3,29]. The clinical implications of language changes; are significant in the symmetry of the dental arch; dental midline; maintenance of treated incisal relationships; open bite. Regarding the differential diagnosis of abnormal tongue posture, one should consider its posture regarding skeletal morphology. A protruded posture of the tongue results in an open bite.

The importance of determining the shape and position of the tongue at the time of the patient’s examination is widely discussed in scientific studies. Regarding the shape of the dental arch, we find that it is determined by the teeth and also by the opposition of the forces of the tongue and the perioral tissues [1], by the correlation between the force of the dental eruption and the resting pressure of the lips and tongue [2], for the resting posture of the lips and tongue in facial morphology during the face growth phase [3]. The forward posture of the tongue is sufficient to cause the vertical eruption of the anterior teeth resulting in an anterior open bite, as the pressure of the lips and tongue can create a pressure at rest influencing the shape of the dental arch and the dental position [2].

Changes during swallowing can occur with atypical pressure of the lower lip, interposing between the upper and lower incisors, to seal the anterior part of the oral cavity, accompanied by increased tone in the musculature of the chin or with atypical pressure of the tongue that can cause the appearance of anterior open bite with or without vestibular incisor reversion or posterior cross bite or lateral open bite together with cross bite [30]. The effects of changes in swallowing in the jaws are extensively studied by orthodontists, orthopedists, speech therapists who need as much information as possible for the diagnosis and planning of cases.

The works involving the dynamics of the tongue in the physiological acts of swallowing, chewing and phonation, are performed by the technique of cinefluoroscopy, a technique that involves high doses of radiation. To view the tongue and upper airways, in cinefluoroscopy, radiopaque substances of varying amounts are used that prevent the observation of teeth. We found in the literature the use of several substances for swallowing, such as: radiopaque cream produced at Nicolas Laboratories Ltd [23]; mixture of barium sulfate and carboxymethylcellulose [21,22], placement of a fine lead marker in the sagittal portion of the tongue associated with barium [22], barium sulfate and semi-spherical lead markers fixed with surgical super-cement to evidence the tongue posture [27].

Radiography together with fluoroscopy, cinefluoroscopy and video fluoroscopy has been used in the diagnosis of swallowing disorders [4]. Although the radiography does not show the dynamics of swallowing, it can bring valuable information if the back and the apex are visible when the patient’s tongue takes on certain positions, the radiography has the advantage of using radiation doses much lower than other techniques and presents, also, lower cost than other exams [23]. The large amount of radiopaque substance needed to perform dynamic examinations prevents the teeth from being seen on cephalometric teleradiographies [23].

The use of barium sulfate despite being described and accepted by the scientific community [13,14,16-18] as an inconvenience the high fluidity dispersing in the oral cavity when used in radiographic shots, making it difficult or even preventing the discernment of other structures.

In our laboratory experiment, the radiographic density of the barium sulphate-based paste proved to be adequate, even when the kilovolt and milliamperage were changed (Figure 5-8). In terms of viscosity, the paste proved to be adequate, as it remained only in its bed and because there was no spreading. In the literature, we found only the study by Guay, et al. (1978), who used radiopaque contrast paste applied throughout the median extension of the tongue, in order to study the resting positions of the tongue and in the emission of phonemes, the Esophotrat Barium Cream paste used by the authors, cannot be found in Brazilian market.

In our work using barium sulfate paste in the radiographic socket, it was possible to delimit and outline the tongue, simulating the different positions it takes during the oral phase of chewing and swallowing, as well as in phonation without harming the cephalometric tracing of the teeth. In figure 9, we observe the simulation of the tongue position next to the buccal floor and in passive contact with the lingual face of the lower incisors [4,29,30]. Other resting positions described in the literature were simulated, the back of the tongue touching the palate lightly while the tip normally remains at rest in the lingual fossa or groove of the lower incisors [4,30] (Figure 10). Figure 13 shows the elevation of the tongue, with the apex moving forward and upwards and coming into contact with the upper incisors or the palatal mucosa [19]. Continuing the swallowing process, figure 14 simulates the rolling of the tongue backwards until it reaches the junction of the soft and hard palates as described in the literature [19]. Because it is a macerated skull and does not have a hyoid bone, its more anterior and superior positioning cannot be observed, as reported by Cleall, et al. (1966) before the tongue returns to the resting position.

**Figure 9:** Tongue at rest.

**Figure 10:** Tip of the tongue touching lower incisors and elevated back.
Figure 11: Tongue projected between the incisors.

Figure 12: Lowered back and tip of the tongue touching lower incisors.
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**Figure 13:** Ponta da língua tocando palato e o dorso rebaixado.

**Figure 14:** Back in contact with hard/soft palate region.

We believe that with the use of radiopaque paste *in vivo* in postero-anterior teleradiographies it is possible to observe the different positions of the [29,31] tongue in function of the lowering of the lateral edge of the tongue on the working side in which the food is being ground while on the side of balance the edge is raised to prevent the food from changing sides during crushing or median tongue depression forming a longitudinal groove, to accommodate the bolus at the beginning of swallowing [29].

The peculiar positions of the tongue, in cases of atypical swallowing, such as the tongue interposing between the incisors, as if it were going to be bitten or between the premolars and the swallowing is performed with a depression of mandible [30] (Figure 11). In cases of open lateral bite during swallowing, the tongue is stuck in the premolar region and swallowing is performed with a depression of the mandible [31] (Figure 15). In some cases of atypical swallowing the tongue is played against the lower teeth, do not come in contact with the palate, having an expanding effect on the lower arch [29].

![Figure 15: PA. Radiography - lateral projection of the tongue.](image)

Mouth breathing is another factor that can cause changes in the positioning of the tongue. To facilitate the entry of air through the mouth, the tongue assumes a lower position and sometimes the upper back is observed in order to regulate the air flow [30] (Figure 10 and 14).

Typically, the phonemes /T/; /D/; /N/ and /L/ are produced with the anterior third of the tongue touching the palate [31] (Figure 14). The projection of the tongue occurs in the emission of the phonemes /T/; /D/; /N/ e /L/ in patients with anterior open bite and in the emission of fricatives /S/ e /Z/ in Class II patients [31] (Figure 11). When emitting phonemes /T/; /D/; /N/ and /L/ in Class III individuals, the movements of the tip of the tongue are replaced by the middle or back of the tongue [31]. The distortion of phonemes /S/; /Z/ occurs due to posterior positioning of the tongue in cases of skeletal Class II with lateral open bite (Figure 15).

Other important diagnostic information, which can be obtained with the use of the paste in radiographic shots, is related to the resting position in the different malocclusions, as reported by Interlandi [29] and Ferreira [31]. The resting posture of the tongue is usually el-
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Elevated in its dorsal portion and lowered at its apex due to the decreased antero-posterior position of the jaws in Class II division 1 (Figure 10 and 14) or the tongue is located between the dental arches (Figure 15); in Class III cases, the tongue is usually hypotonic, enlarged, flat or elevated, accommodated on the floor of the mouth [30] (Figure 10); in cases of anterior open bite, the tongue is usually protruding [29,30] (Figure 11).

The possibility of visualizing the apex and the edges of the tongue, also allows the realization of tracings in which they are taken into account as those described by several authors [5-7,19,32-34].

The tongue posture is examined clinically with the mandible in a postural resting position. A sagittal cephalometric record of this relationship is also indicated. The cephalometric analysis is accurate, reproducible and simple, it can be used in the private clinic. The use of radiopaque contrast (such as barium paste) on the tongue allows visualization during palatography.

In addition to the superiority in the radiographic density of barium sulfate in relation to iodinated contrasts [15,16] and despite the dilution of barium sulfate showing a reduction in radiopacity [18], the paste used in our study did not present this disadvantage even when subjected to exposure factors, higher than those commonly used for lateral teleradiographies. The paste also has as advantages the fact that it is inert in the light of the gastrointestinal tract, does not cause an unfavorable effect and is inexpensive.

As this is a laboratory study in which there are no factors that can compromise the performance of the paste (such as human behavior, saliva), studies in humans will be carried out in the near future.

Conclusion

Within laboratory conditions, the barium sulphate-based paste proved to be effective in presenting adequate radiopacity and viscosity, easy to be placed inside the cavity, compatibility with the lingual tissue. In addition, barium sulphate-based paste has a low cost, making clinical examination feasible.

Bibliography

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