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A new classification of wind instruments: Orofacial considerations

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ABSTRACT

Background/objective: Playing a wind instrument implies rhythmic jaw movements where the embouchure applies forces with different directions and intensities towards the orofacial structures. These features are relevant when comparing the differences between a clarinettist and a saxophone player embouchure, independently to the fact that both belong to the single-reed instrument group, making therefore necessary to update the actual classification.
Methods: Lateral cephalograms were taken to single-reed, double-reed and brass instrumentalists with the purpose of analyzing the relationship of the mouthpiece and the orofacial structures.
Results: The comparison of the different wind instruments showed substantial differences. Therefore the authors purpose a new classification of wind instruments: Class 1 single-reed mouthpiece, division 1– clarinet, division 2 –saxophone; Class 2 double-reed instruments, division 1– oboe, division 2– bassoon; Class 3 cup-shaped mouthpiece, division 1– trumpet and French horn, division 2- trombone and tuba; Class 4 aperture mouthpieces, division 1– flute, division 2 – transversal flute and piccolo.
Conclusions: Elements such as dental arches, teeth and lips, assume vital importance at a new nomenclature and classification of woodwind instruments that were in the past mainly classified by the type of mouthpiece and not taking into consideration its relationship with their neighboring structures.

1. Introduction

During the last decades, there has been an increase interest in the area of performing arts medicine. Issues regarding the general health of a musician and specific considerations involving physical and psychological of instrumentalists have been published.[1–3] Nevertheless, performing arts dentistry is a subject where more investigations should be carried out to understand and evaluate the possible impacts of musicians oral health in his/her performance.

Surely, the orofacial region can induce more limitations to the performer depending on the musician role, e.g. a singer, a violin player, or a clarinetist. Usually, the dentofacial morphology can have direct implications on the stomatognathic function with the tongue adopting different positions, which can be crucial for the production of the sound. The shape of the dental arch, the height of the palate and temporomandibular joint hypermobility can represent the main issues of the oral health of a singer. Apart from these factors, the missing of a natural anterior tooth is also crucial for the perfect articulation of the sound quality. The influence of the previous craniofacial structures is also important for wind and string instrumentalists, where the movement of the masticatory muscles and the direction of forces are usually not harmonized. This coordinating action involves a complex neuromuscular system of the jaws, where the occlusion, the temporomandibular joints (TMJs) and the teeth have a high factor of importance and influence, especially in wind instrumentalists.

Grammatopoulos studied the effects of playing a wind instrument on the occlusion and found that it did not influence the position of the anterior teeth, not being a major etiologic factor in the development of

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a malocclusion.[4] Nevertheless, this author referred that playing a brass instrument with a large cup-shaped mouthpiece might predispose a musician to develop lingual crossbites, or lingual crossbite tendencies. Understanding the embouchure characteristics of each wind instrument player is also vital to correlate the intermittent forces in tooth movement/displacement and root resorption.

In 1939, Strayer defined a classification for wind instruments where he grouped wind instruments based on mouthpiece features into four classes [5]: a) instruments with the mouthpiece shaped like a 'cup' (e.g. trumpet, cornet, horn, trombone, tube, euphonium, French horn); b) instruments with a single wooden reed (e.g. clarinet, saxophone); c) instruments with a double wooden reed (e.g. oboe and bassoon); and d) instruments with a mouthpiece in a shape of a single opening (e.g. flute). The distinction between the aforementioned groups is related to the interaction between the mouthpiece and the oral cavity, or, as typically is addressed, the musicians' embouchure. Strayer's motivation behind this taxonomy was to identify groups of instruments that share the same forces on the dentition and which can create malocclusions or escalate existing anomalies in the oral cavity. It is unquestionable the importance of the embouchure not only in tone formation, but also to the medical conditions of the oral cavity. However, while apparent links can be established within Strayer categories, it can be argued that the various instruments under each group present significant differences from a performance viewpoint, which may claim for a different or refined taxonomy.

There should be a special focus on the position adopted by the mouthpiece regarding the teeth, the lips and the perioral tissues. Therefore, this study investigated the interrelationship mouthpiece/orofacial structures generated during the embouchure in order to provide a new classification of wind instruments. The identification of a recognizable pattern associated to the embouchure should be analyzed in detail in order to provide a new classification of wind instruments.

2. Materials and methods

2.1. Sample selection

From an acoustic standpoint, wind instruments are typically grouped into two families: brass instruments, such as trumpet, trombone, French horn and tuba; and woodwind instruments, such as clarinet, saxophone, oboe, bassoon and flute. Historically, this distinction was due to the material of the instruments. In order to verify that the orofacial relationship observed during the embouchure of brass instruments can surely be different when comparing and evaluating a tuba player or a trumpet player, cephalograms, were taken in order to carefully evaluate these parameters. This radiographic examination was also carried out for single and double-reed instrumentalists.

This research was approved by the Ethics Committee of Faculdade de Medicina Dentária da Universidade do Porto, Portugal. The sample was composed of 38 volunteers that were professional musicians and represented each wind instrument involved in the new classification, 7 saxophone, 5 clarinet, 1 oboe, 4 bassoon, 6 trumpet, 4 French horn, 4 tuba, 4 trombone, 2 transversal flute and 1 flute. The volunteers inclusion criteria were: complete permanent dentition and absence of previous orthodontic treatment.

2.2. Radiographic examination

Lateral cephalograms were taken with the purpose of analysing the relationship between the mouthpiece and the orofacial structures. The wind instrumentalists were asked to perform the physiologic phenomena of the embouchure at a medium registration during the complete procedure, while acquiring lateral cephalometric radiographs (Fig. 1). These were obtained using a standard technique, by the same technician, with the patients in a standing position while wearing an X-ray apron; the head of the patient was oriented in the Frankfurt horizontal plane. This procedure was repeated to all wind instruments, single-reed, double-reed and brass.

Nevertheless, due to the size of the tuba, this musician even seating on a bench was not able to adjust himself with his instrument to the dimensions necessary to take the cephalometric radiographs. To solve this limitation, the musician was holding the mouthpiece, while performing the embouchure, as usually during a musical performance (Fig. 2). The equipment used to obtain the radiographic images was the (Orthoralix®, Gendex, U.S.A.).

2.3. Cephalometric tracing for embouchure analyses (CTEA)

This analysis was only done for saxophonists, clarinetists and trumpet's players, due to the small number of participants of the other classes of wind instrument. To confirm the reproduction of the embouchure mechanism between instrumentalists of the same class of wind instrument, it was traced for the single-reed instruments a line going parallel with the upper part of the mouthpiece and for the trumpet a line was traced parallel to the circular and labial aspect of the mouthpiece that contacted with the lips. Then, it was recorded the cross angle obtained between the traced line of the respective mouthpiece and the Frankfurt plane.

3. Results

The comparison of the different wind instruments on the lateral cephalograms showed substantial differences between them. Taking into account anatomical and physiological considerations of the wind instrumentalist's embouchure, there is the need of promoting a new classification of wind instruments. This data is important to understand that the contact forces between the dental structures and the mouthpiece during musical performance and embouchure of a tuba show dissimilarities from a trumpet, regarding orofacial considerations. There is no concern to determine and correlate the vertical relations of the maxilla and the mandible; this new classification intends only to make visible important observations from a clinical standpoint, by observing the dentoalveolar relationship during the embouchure of each musician.

The following figures show the new proposed classification of wind instruments regarding the above mentioned factors during the embouchure and present the differences among these four groups. **Class 1 instruments** with single-reed mouthpiece, division 1 – clarinet and division 2 –saxophone, (Fig. 3); **Class 2 instruments** with double-reed instruments, division 1 – oboe and division 2 – bassoon, (Fig. 4); **Class 3 instruments** with cup-shaped mouthpiece, division 1 – trumpet and French horn, division 2- trombone and tuba, (Fig. 5); **Class 4 instruments** with aperture mouthpieces, division 1 – flute, division 2 – transversal flute and piccolo, (Fig. 6). Within these groups there is a subdivision according the position adopted by the mouthpiece (see Figs. 7–12). For the cephalometric tracing for embouchure analyses it was obtained the following (see Table 1).

The most noticeable and remarking result of this study is the differences of the lateral cephalograms among each type of instrument, and between the single-reed, the double-reed and the brass instruments. It is therefore essential that musicians, dentists and researchers take into consideration that playing a clarinet will not be the same as playing a saxophone, even if they are classified inside the same family of instruments, the single-reed instruments. There are significant differences in the embouchure regarding the orofacial structures, which also happens in the double-reed instruments and the brass instruments.

Class 1 instruments, the saxophone mouthpiece should enter the mouth at a 'flatter' angle than the clarinet (approximately 20°). These different angles have considerable implications on how the pressure is exerted in the mouthpiece. For example, in the case of the clarinet, by bringing the instrument closer to the body in a vertical position, the lower lip ends up further down the mouthpiece, allowing the reed more

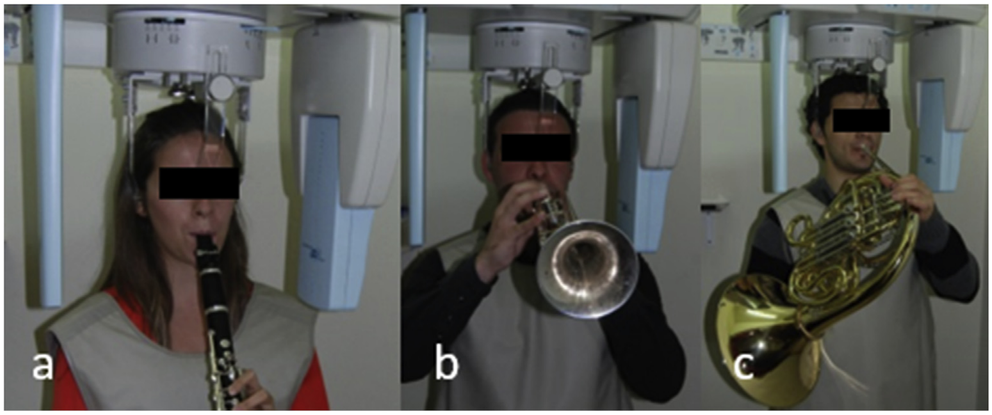

Fig. 1. Acquisition of wind instrumentalists lateral cephalometric radiographs.

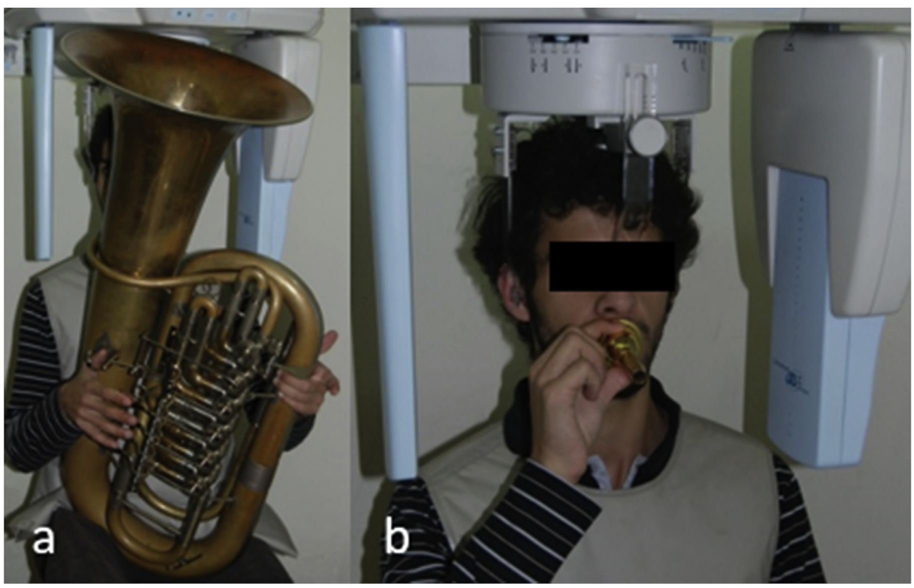

Fig. 2. Tuba player with space limitations within the radiographic equipment.

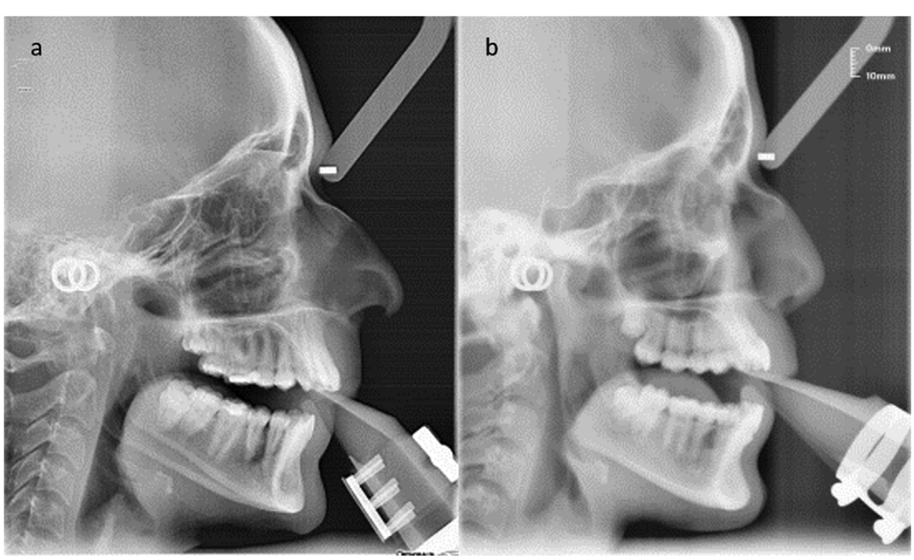

Fig. 3. Class 1 - Instruments with single-reed mouthpiece, division 1– a) Clarinet, division 2– b) Saxophone.

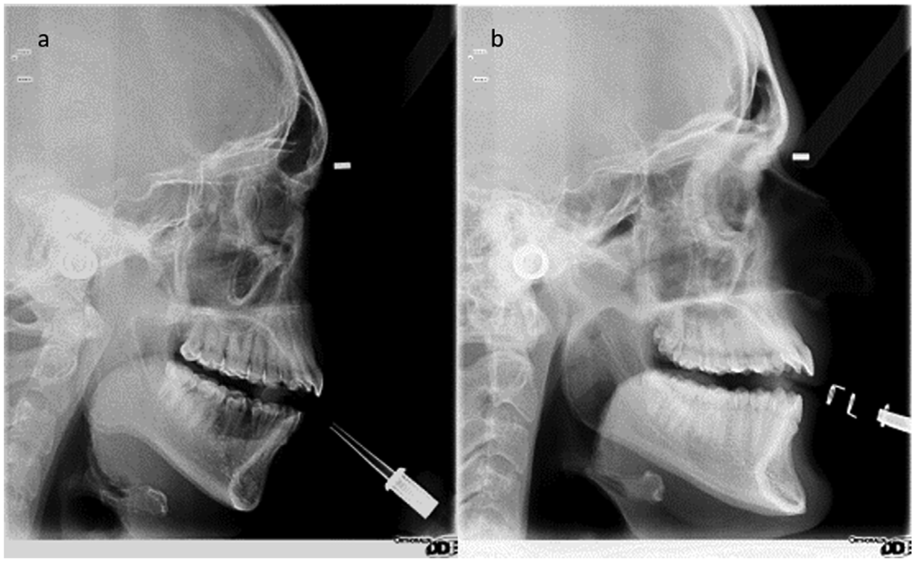

Fig. 4. Class 2 - Instruments with double-reed instruments, division 1– a) Oboe, division 2– b) Bassoon.

freedom to vibrate. Using a flatter angle such as in the saxophone, the upper and downward lips and dentition contact the mouthpiece in roughly the same location.

Class 2 instruments, the oboe and bassoon reeds have different playing angles, with the oboe adopting a close to vertical position inside the mouth. The teeth should remain open and far apart while playing with the corners of the embouchure forward, allowing the two-coupled reeds to vibrate.

Class 3 instruments, the first evidence in performance is the size of the mouthpiece. The lower the sound of the instrument, the larger the mouthpiece. This naturally changes the contact point between the mouthpiece and the lips, as well as the amount of lip that will vibrate inside of the mouthpiece. Thus, a trumpet or horn player, for example, have considerable less lip inside the mouthpiece in comparison with a tuba player, which have more lips vibrating inside the mouthpiece. Furthermore, the difference in the size of the mouthpiece has implication in its placement, i.e. the contact point between the mouthpiece's rim and the player's mouth. Low brass players can even find it hard to keep the placement low enough because nose or chin can get in the way of an ideal (personal) contact point, because they do not have enough room to place the larger mouthpieces in a desired ratio of upper to lower lip that the performers are comfortable with. High brass players also need to be more concerned about placing their mouthpieces consistently in the same place on their lips compared with low brass players. This happens since the mouthpiece is smaller; therefore, a minimal change in the position adopted during the embouchure can have a huge implication on the tone formation.

In other words, based on these results, the existing differences of the contact point between the mouthpiece and the perioral tissues will determine the subdivision in the Class 3 instruments division 1 – like trumpet, French horn, cornet, and horn which have a mouthpiece with a small diameter and division 2- like trombone, tuba and euphonium that have a mouthpiece with a larger diameter.

Class 4 instruments, the typical embouchure requires the lower lip to be rolled over and in contact with the hole in the headjoint of the flute, whilst the upper lip is stretched or drawn downwards to create a particular lip aperture and teeth position, which then focus and direction the air stream into the flute headjoint hole. Once more, owing to the current inclination of the mouthpiece regarding the orofacial structures the sub-division of the Class 4 instruments, takes in consideration a more vertical and necessary placement of the flute – division 1. On the other hand, a more horizontal position is adopted by the transversal flute and the piccolo during the embouchure – division 2, with significant differences from the previous instrument.

The results of this study do not take into consideration the possible discrepancies between the sagittal jaw relation and other parameters, like overjet or overbite. The chance of the existence of a malocclusion between musicians, and the possible varieties of morphologies that can be present between the general musical population, can lead to an adaptation of the embouchure regarding an equilibrium of the teeth, jaws and lips. As an example, a saxophonist with a malocclusion type Class III, with a sagittal relation of the mandible bigger than the maxilla, will have the same inclination of the mouthpiece if he has a normal occlusion. The major issue will be the existing differences in the

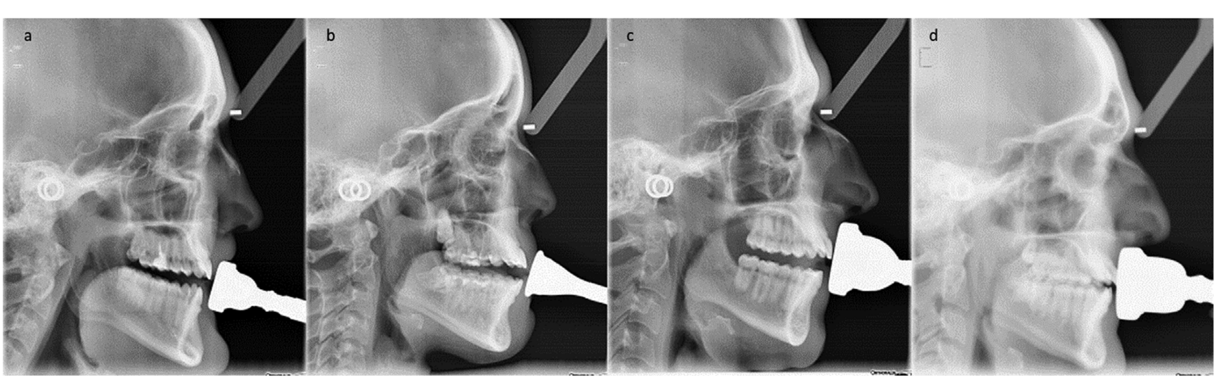

Fig. 5. Class 3- Instruments with cup-shaped mouthpiece, division 1– a) Trumpet and b) French horn, division 2- c) Trombone and d) Tuba.

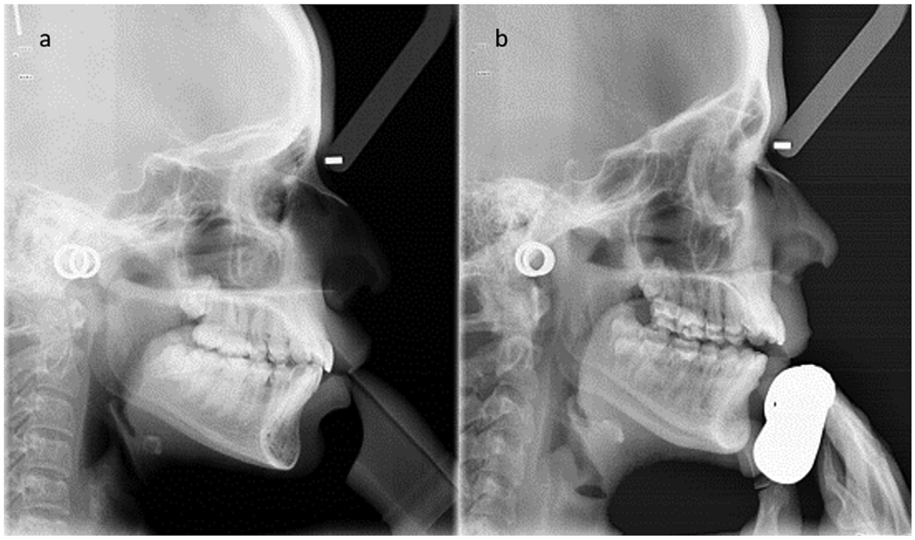

Fig. 6. Class 4 – Instruments with aperture mouthpieces, division 1– a) Flute, division 2– b) Transversal Flute and Piccolo.

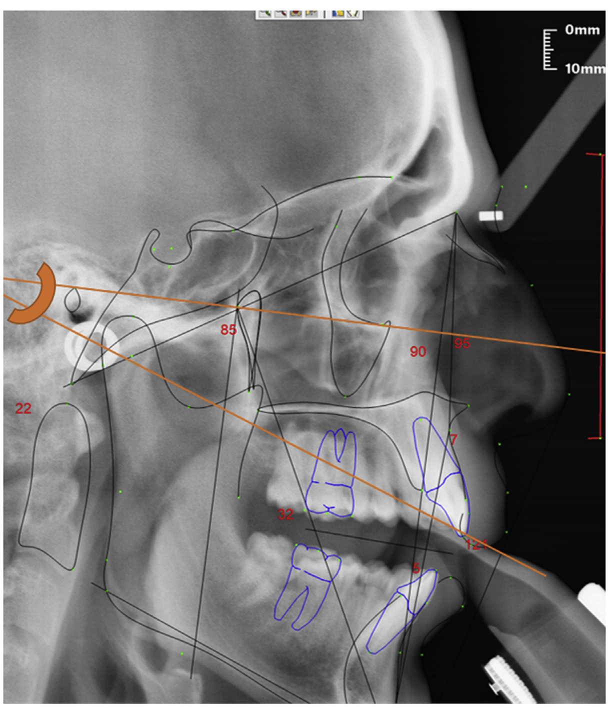

Fig. 7. Cross sectional angle between the Frankfurt horizontal plane and a line delineate at the superior part of the clarinet's mouthpiece.

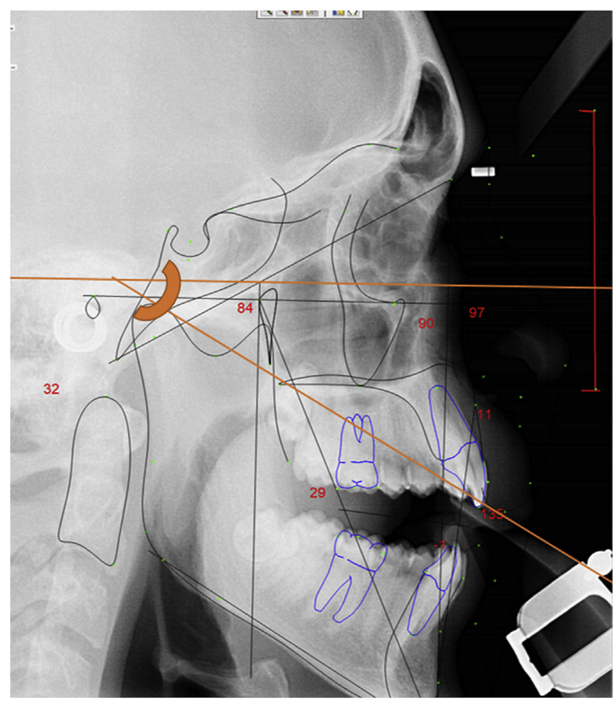

Fig. 8. Cross sectional angle between the Frankfurt horizontal plane and a line traced at the superior part of the saxophone's mouthpiece.

biomechanics of the temporomandibular joint, regarding musical performance in order to achieve the different registrations. To our understanding, this will induce the musician to promote a muscular hyperactivity of the masticatory muscles with a more precise adaptation and movement of the temporomandibular joint to compensate the maxilla-mandibular discrepancies. The verticalization or retroinclination of the incisors of the upper or lower jaw will oblige the soft tissues such as the lip to follow their inclination. Independently to all of the above mentioned orofacial issues the angle and position of the mouthpiece inside the mouth of a clarinet or saxophone player will be different.

4. Discussion

The revision of a new classification of wind instrumentalists should be considered among dental education, conservatoires and music colleges. This new classification considers the position adopted by the musician during their embouchure in relation to the orofacial structures such as the teeth, lips and jaws. This leads to the importance of quantifying these anatomical features and promoting this new classification of wind instrumentalists. Nevertheless, in this particular study there was a morphological similarity between the different groups. The proposed classification of wind instrumentalists will be explained hereafter presenting their unifying elements as well as pinpointing the differences between the various instruments in each group.

4.1. Class 1 - instruments with single-reed, division 1 – clarinet and division 2 –saxophone

In this category, it was first examined single-reed woodwind instruments, and exposing the main differences between the two common

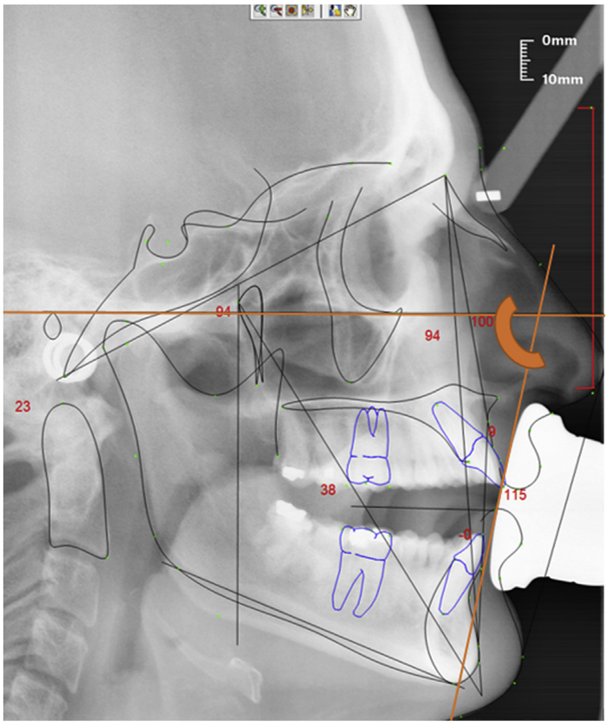

Fig. 9. Cross sectional angle between the Frankfurt horizontal plane and a line traced at the superior part of the tuba's mouthpiece.

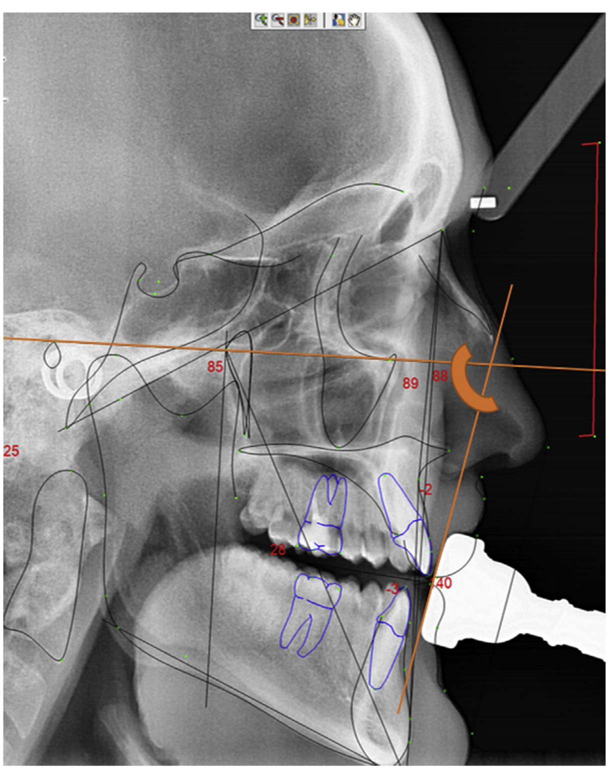

Fig. 10. Cross sectional angle between the Frankfurt horizontal plane and a line delineate at the circular aspect of the trumpet's mouthpiece.

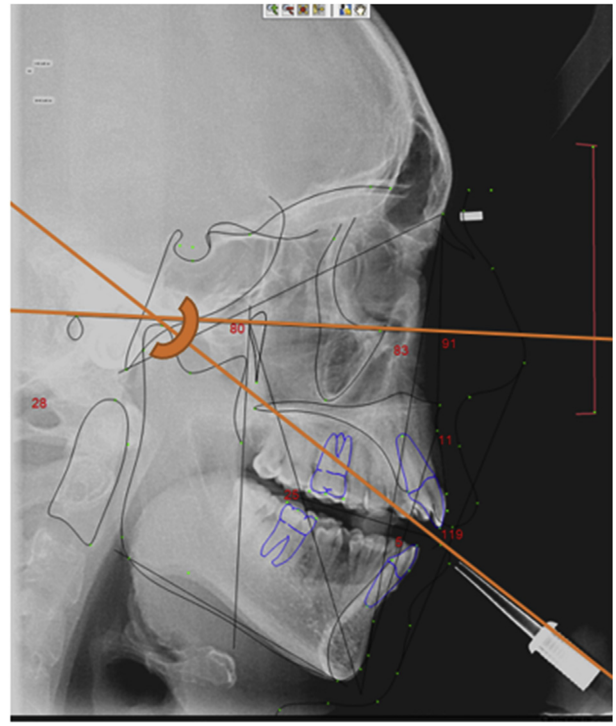

Fig. 11. Cross sectional angle between the Frankfurt horizontal plane and a line traced at the superior part of the oboe's mouthpiece.

single-reed instruments, the Bb soprano clarinet and the Eb alto saxophone. While many basic aspects of embouchure formation are the same for all single-reed instruments, there are also important differences, of which the most noticeable one is the angle of the mouthpiece in the player's mouth.[6] Roughly speaking, the angle of the clarinet is more acute than the saxophone and other woodwinds, closer to 35°.[7] Although this angle is widely accepted, this must be re-examined and adapted according to the clarinettist facial structure. Furthermore, the mouthpiece angle in these two instruments imposes hard constraints to the oral cavity, directly affecting the air stream. Clarinettists have larger degree of freedom than saxophonists, and renowned pedagogues of both instruments claim different strategies, as ideal tongue positions (the muscle that most contributes to changes to the air stream in the oral cavity). Clarinettist promote that the tongue should remain forward, rather than pulled back. The mid-section of the tongue should be high and back, which narrows the space of the oral cavity and allows the air to speed up. Saying words like “key” and “kick,” or hissing like a cat, arches the tongue back and up into the right position.9 Saxophonists identify a more downward position of the tongue (i.e., “EE” position, as in “eat”) as most effective.[8–10]

Another variable one must consider is the different size of the mouthpieces in single-reed instruments, thus requiring small changes to the examples previously reported. Both, clarinet and saxophone families of instruments include various models, whose major difference is the pitch range. Generally speaking, by increasing the openness of the embouchure, the stiffness of the embouchure tends to decrease. Therefore, the lower pitched clarinet and saxophones commonly require a more open and relaxed embouchure than the higher pitched instruments of their families. Overall, single-reed high-pitched instruments use a noticeably firmer embouchure. Intrinsically related to the stiffness of the embouchure, is the acoustic impedance or blowing pressure, which in the clarinet tend to decrease while increasing pitch height, and decreased in the case of the saxophone, thus presenting the opposite tendency.[11]

Moreover, taking into consideration the CTEA, the relationship between the mouthpiece and the orofacial structures in clarinetists is different than in the saxophonists. The angle formed with the mouthpiece and the Frankfurt plane is greater in the clarinetists than in the saxophonists. This characteristic path of mouthpiece insertion unlike for single-reed instruments may be easily explain by the form of the instrument itself. The clarinets are straight and in contrast all

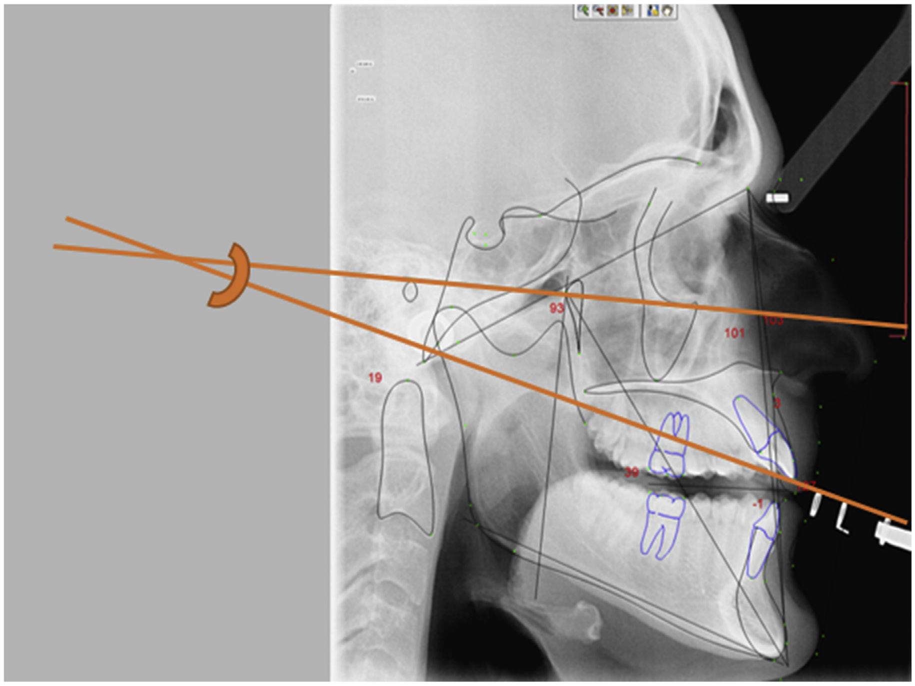

Fig. 12. Cross sectional angle between the Frankfurt horizontal plane and a line traced at the superior part of the bassoon's mouthpiece.

Table 1
Cross angle obtained between the Frankfurt horizontal plane and the mouthpiece's long axis.

Saxophone	Clarinet	Trumpet	Tuba	Oboe	Bassoon
14°	26.5°	63°	81°	36°	12°
19.5°	35.5°	63°	79°		11°
19°	30°	78°	83°		16°
22°	35°	78°	83°		11°
16°	24°	73°			
18°		74.5°			
17.5°					
Average 18°	***Average*** **30.2°**	***Average*** **71.6°**	***Average*** **81.5°**	***Average*** **36°**	***Average*** **12.5°**

saxophones (with the exception of the soprano) have a “s” curvature at the neck. Once we have the same fulcrum (at the incisal border of the lower incisors) for both instruments, but the axis of rotation is slightly different, consequently the leverage effect will be different. Thus, a completely different embouchure approach at the level of the stomatognathic system, in the same class of wind instruments, can be present. Following this argument, saxophonists may apply a greater force at the level of the mandible than the clarinetists, and on the other hand, the clarinetists may apply a greater force at the incisal angle of the upper central incisors than saxophonists. Thus, future researches in this area with piezoresistive sensors would be helpful to determine the forces applied to the orofacial structures when performing the embouchure.

4.2. Class 2 - instruments with double-reed, division 1– oboe, division 2– bassoon

In this category falls the oboe and bassoon instruments and their large (historical) instrument families, whose common characteristic is the use of a double-reed with a contact point between the oral cavity and the instrument. Both, oboe and bassoon feature a round embouchure that surrounds the double-reed with ideally equal pressure from the top and bottom lips.

Another crucial difference between these instruments, is the amount of reed in the oral cavity. While oboe and bassoon reeds do not vary drastically in length, (oboe reeds are generally between 68 mm and 72 mm, bassoon reeds are about 60.8 mm–60.33 mm). Yet, for a controlled tone formation, oboe reeds should have approximately 1/3 of the reed inside the mouth, while bassoon reeds should contact about 2/3 of the way onto the oral cavity. This difference also imposes significant differences to the freedom of the oral cavity muscles, as previously discussed in the comparison between the saxophone and clarinet.

An additional significant difference is the pressure exerted during playing. Although blowing pressure profile of both instruments is correlated in the sense the higher the pitch, the higher will be the airflow pressure applied. The oboe tends to present an overall mean blowing pressure much higher than the bassoon.[11] This fact explains why the bassoon embouchure tends to be much looser. Generally, a little more of the upper lip is visible with the bassoon embouchure, and thus virtually none of the reed part of the lower lip is visible.

Although the sample contained only one oboe player, comparatively with the four bassoon players it was possible to observe that the angle obtained in the CTEA was different. The oboe player showed a higher CTEA angle than the bassoon players. Thus, the insertion of the mouthpiece in the stomatognathic system relatively with the Frankfurt plane may be different for the double-reed instruments, oboe and bassoon.

4.3. Class 3 - instruments with cup-shaped mouthpiece, division 1– trumpet and French horn, division 2- trombone and tuba

This category includes instruments such as trumpet, French horn, cornet, horn, trombone, tuba, euphonium, which have in common the use of a rounded metal mouthpiece that fits comfortably against the lips. Trumpet and trombone mouthpieces are usually semi-spherical (cup shaped) whereas French horn mouthpieces are conical. Naturally, the differences of the mouthpiece rim diameter in brass instruments reduce the amount of the lips that moves, and is known to affect tone formation.[12]

The embouchure(s) of this group of musicians, and in particular the lips, act as a self-sustained oscillators, which modulates the air flow.[13]

In fact, brass players can make musical sounds with just their lips. This is in fact a widely known exercise for brass players, called 'buzzing', which renowned pedagogues advocate as ideal to warm up the muscles and to train embouchure flexibility. It consists of closing the mouth, pull your lips back in a strange smile, and blow. The more tension you apply to your lips (the harder you pull your lips backwards in a smile), the more quickly they spring back into position, and thus the higher the frequency of the produced note. The result may be anywhere between a low pitched 'raspberry' or a high pitched musical note, depending on the tension and the geometry of the lips (how hard are they pulled backwards, and how hard are they blowing). If else equal, high lip tension gives high frequency and so high pitch.

Apart from these aspects, there is always the need to understand slight deviations on the embouchure of brass instrumentalists independently if they belong to the sub-group division 1 or division 2. Morphological characteristics can be the origin of these changes, but tone quality can be another important factor to take in consideration due to the lip vibration particularly inside the mouthpiece. The low brass instruments generally have the lips evenly divided half upper and half lower. Contrarily, the contact point between the lips and the mouthpiece on high brass instruments tends to be uneven. Different pedagogues advocate different strategies. Typical approaches to the trumpet or horn embouchure are related to the result of the airflow direction, which can be either up or down. This different air stream direction is determined by different ratios between the upper to lower lip inside the mouthpiece. When the mouthpiece is placed with more upper than lower lip inside the mouthpiece, the air stream blown down. When the mouthpiece is placed with lower lip, the air stream blown up. The individual player's anatomy would be the most important determining factor in which embouchure would work best for a particular player. Pedagogues advocate different strategies, yet as a rule-of-thumb is common to indicate approximately one third of the upper lip and two thirds of the lower lip for an upstream embouchure, and two thirds of the upper lip and one third of the lower lip for a downstream embouchure. Soloists, pedagogues and well-respected authors claim slightly different approaches. For example, Arban states that the mouthpiece should be placed 1/3 on the upper lip.[14] On the contrary, Jacome claims that the mouthpiece should be placed two-thirds for the upper and the rest for the lower lip.[15] Farkas acknowledges three common embouchure positions: very high, medium and low placement embouchure type.[16] These categories are related to the ratio of upper to lower lip inside the mouthpiece that made the embouchure upstream or downstream. When the mouthpiece is placed with more upper than lower lip inside the cup, the air stream gets blown down. When the mouthpiece is placed with more lower lip, the air stream gets blown up.

As discussed, the mouthpiece placement should take into consideration the direction of the air and adjust appropriately, yet, one must not ignore the dental characteristics of the players, which are critical to the mouthpiece placement, as they have huge implications in the air stream direction. These considerations are fundamental to understand this new classification for brass instruments where the embouchure can induce a higher vibration of one particular lip, or even the placement of the lip inside the mouthpiece. Nevertheless, with all these possible adjustments, the contact point of Class 3 division 1 instruments will always be on the crown, while division 2 instruments, due to the extension of the mouthpiece diameter, will embrace the area of the teeth's root.

When comparing the CTEA of the trumpet players with the tuba players a small difference of the angle was found. The tuba players tend to have their mouthpiece in a more vertical position than the trumpet players in relation to the Frankfurt plane. Since the role of the upper lip and of the pre-maxilla in tuba players for stabilizing the instrument's mouthpiece is greater than in trumpet players, this will result in a more perpendicular angle with the Frankfurt plane.

4.4. Class 4 - instruments with aperture mouthpieces, division 1– flute, division 2– transversal flute and piccolo

The last category includes the flute, the transversal flute and the piccolo. Contrary to all aforementioned discussed woodwind instruments, these instruments do not act as a close tube. Adjusting the tension of the upper lip whilst maintaining the lower lip inactive produces variation in tone formation. Additionally, back and forth movements between lips gives control over register changes, pitch and dynamics. Of course, one needs also a good control of air speed and pressure, but the flexibility is what makes the control of register, pitch and dynamics possible. To produce a variety of sounds or tone colours, infinite adjustment of the basic embouchure is necessary. Low register requires less blowing pressure, and a lower air stream direction (pedagogues recommend that 60% of the air stream to be directed towards the head joint hole). As higher is the pitch, the bigger the tendency to over blow and to direct the air stream more horizontally, i.e. the ratio of air that goes inside to outside of the headjoint hole is smaller.[17]

The use of lateral cephalograms and its analysis together with instrument correctly placed in the orofacial structures may be another approach to study the skeletal relationship of the cranio-cervico-mandibular complex with the wind instrument. Other researches have used the MRI to study the movements of the tongue in trumpet players and horn players.[18,19] However comparing the lateral cephalogram with the MRI the position of the wind instrumentalists' cranio-cervico-mandibular complex will be in a more correct anatomical position and therefore in more normal embouchure position. When in supine position the mandible tends to move to a more posterior position together with the tongue[20,] which may result in a different moving pattern of the mandible and tongue and with different muscle demands. The major importance of understanding this new wind instrument classification, can also be highlighted in the research done by Clemente et al. where significant differences of the embouchures pressures can be quantified even when dealing with an instrument of the same type, a double reed instrument. In this work Clemente et al., demonstrated the existing differences between the pressure exerted by the mouthpiece of an oboe and an English horn in the same musician, and the differences adopted by the orofacial structures regarding the different instruments, which was possible to observe with the lateral cephalograms of the musician's embouchure with the oboe and English horn.[21] This is in accordance to what the authors intend to highlight with this new classification of wind instrumentists, which is that if this occurs within the same type of instrument in this case a double reed instrument, the necessity of understanding the existing differences of the embouchure of a clarinet and a saxophone should be validated, or in the same manner the existing differences between an oboe and bassoon, or even within the brass instruments, which should be subdivided since the lateral cephalograms and analyses implemented on this study validates this premise.

Some limitations of the lateral cephalogram for the purpose of studying the embouchure that the authors found were: the bad visibility of the soft tissue organs, larger wind instruments do not fitted in the x-ray equipment, required a specialized imaging technician, it exposes the participant to ionizing radiation and only provided two dimensional information.

5. Conclusions

Wind instrumentalists have particular specificities during their embouchure, being essential to highlight the interface of the mouthpiece and the orofacial structures, which were shown by the lateral cephalograms. With this approach, the implementation of this new classification should be taken into account from a medical and musical point of view. Performing arts medicine has in dentistry an important support to understand various dilemmas involved in the activity of musicians. In this particular case, an area so unique and precise like the embouchure, can be analyzed with accurate imaging studies of the lateral cephalograms that capture a dynamic interaction of the mouthpiece inside the mouth of the musician.

Elements such as the dental arches, the teeth and the lips, assume vital importance in the new nomenclature and classification of woodwind instruments purposed. On contrary, the current classification is based in the type of mouthpiece and does not take into consideration its relationship with their neighboring structures.

6. Patents

No patents may or will result from this work.

Conflicts of interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jobcr.2019.06.010.

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