Original Article

The association of malocclusion and trumpet performance

Katherine Kula[a]; H Zeynep Cilingir[b]; George Eckert[c]; Jack Dagg[d]; Ahmed Ghoneima[e]

ABSTRACT

Objective: To determine whether trumpet performance skills are associated with malocclusion.

Materials and Methods: Following institutional review board approval, 70 university trumpet students (54 male, 16 female; aged 20–38.9 years) were consented. After completing a survey, the students were evaluated while playing a scripted performance skills test (flexibility, articulation, range, and endurance exercises) on their instrument in a soundproof music practice room. One investigator (trumpet teacher) used a computerized metronome and a decibel meter during evaluation. A three-dimensional (3D) cone-beam computerized tomography scan (CBCT) was taken of each student the same day as the skills test. Following reliability studies, multiple dental parameters were measured on the 3D CBCT. Nonparametric correlations (Spearman), accepting $P < .05$ as significant, were used to determine if there were significant associations between dental parameters and the performance skills.

Results: Intrarater reliability was excellent (intraclass correlations; all r values $> .94$). Although associations were weak to moderate, significant negative associations ($r \leq -.32$) were found between Little's irregularity index, interincisal inclination, maxillary central incisor rotation, and various flexibility and articulation performance skills, whereas significant positive associations ($r \leq .49$) were found between arch widths and various skills.

Conclusions: Specific malocclusions are associated with trumpet performance of experienced young musicians. (*Angle Orthod.* 2016;86:108–114.)

KEY WORDS: Occlusion; Music

INTRODUCTION

The relationship of malocclusion and wind instrument performance is well recognized, but controversial.[1–7] Some authors suggest that selecting the wind instrument to fit the malocclusion of a child might produce a motivated and successful musician, whereas other authors recommend that instrument selection should be made to correct malocclusion.[1–9]

The quality of performance of a wind instrument such as a trumpet is affected by such physical factors as the embouchure; facial and tongue muscle strength; flexibility; coordination; and the volume, speed, and consistency of air blowing through the trumpet.[10] The embouchure, the intimate relationship of the mouth and its musculature to the mouthpiece of the wind instrument, controls airflow from the mouth through the lip aperture to the instrument. The embouchure changes with the type of wind instrument but is important with each.[1,2] Brass instruments with cup-shaped mouthpieces placed extraorally are divided into two groups: small cup and large cup.[1] The trumpet and French horns have small cup mouthpieces that are pressed against the upper and lower lips to prevent escape of air, whereas the trombone and tuba have large cup-shaped mouthpieces that are placed around and outside the lips sealing air escape.

The velocity of air passing into a wind instrument is controlled by the embouchure and the respiratory system.[11] Opening or closing the aperture of the lips changes the pitch of the sound to be higher or lower,[6,12]

[a] Endowed Professor and Department Chair, Department of Orthodontics, Indiana University School of Dentistry, Indianapolis, Ind.

[b] Instructor, Department of Music, State Conservatory, Anadolu University, Eskisehir, Turkey.

[c] Biostatistician Supervisor, Department of Biostatistics, School of Medicine, Indiana University, Indianapolis, Ind.

[d] Instructor, Department of Mathematics and Statistics, Northern Kentucky University, Ky.

[e] Assistant Professor, Department of Orthodontics, Indiana University School of Dentistry, Indianapolis, Ind.

Corresponding author: Katherine Kula, Department of Orthodontics and Oral Facial Genetics, Indiana University School of Dentistry, 1121 W. Michigan St, Indianapolis, IN 46202

Accepted: January 2015. Submitted: November 2014.
Published Online: March 20, 2015

 DOI: 10.2319/111214-812.1

Table 1. Exercises Used to Evaluate Trumpet Performance

Exercise	Description	Measure
Flexibility		
Exercise A	Quickest tempo while moving up/down between adjacent partials	beats per minute
Exercise B	Quickest tempo while slurring nonadjacent partials up/down	beats per minute
Exercise C	Quickest tempo while alternating between adjacent intervals	beats per minute
Articulation		
Exercise A	Quickest tempo for single tongue	beats per minute
Exercise B	Quickest tempo for double tongue	beats per minute
Exercise C	Quickest tempo for triple tongue	beats per minute
Exercise D	Maximum number of semitones above middle G for flutter tongue	half steps
Range – High	Maximum number of semitones above note C5	half steps
Endurance	Maximum continuous play while holding the notes above a set sound level, breathing when needed	seconds

whereas the loudness or softness of the sound is controlled by the glottis.[12] Tensing or compressing the lips changes the aperture of the trumpet embouchure and requires muscle participation. High notes require more muscle tension, thus more pressure on the teeth, whereas low notes require less tension. Herman[6] showed on lateral cephalograms that while playing high notes trumpet players had thin lips, whereas the lips did not thin as much when playing low notes. In addition to acting as a seal to prevent escape of air, lips vibrate to produce air vibrations in the trumpet,[6] resulting in production of sound waves. The position of the tongue influences the embouchure and controls the flow of air.[6]

The trumpet mouthpiece rests on both lips, with the exact amount and position varying depending on the player. Many players are trained to rest the trumpet mouthpiece more on the upper lip than the lower lip,[13,14] whereas others rest it equally between the two,[6] and others pivot the mouthpiece on the lower lip.[12] The position of the mouthpiece and the continuous adjustments in oral musculature can change the pressure on the dentition and cause discomfort for the trumpeter,[6] hypothetically changing the quality of performance.

The lingual force applied on the lips during trumpet playing is hypothesized to have various effects including causing tooth movement, although this point is controversial.[2,3,6,15–26] The lingual force of trumpet playing is also hypothesized to affect the quality of trumpet performance. Orthodontic problems are listed as one of the most common orofacial disorders affecting musicians.[27] Trumpeters who practice many hours complain of loose front teeth.[6] Eleven percent of junior high musicians complained of pain in either the upper or lower front teeth because of long practice sessions, dental spacing or unevenness, or a sharp edge or point on a tooth.[2] Multiple authors[6,28–30] suggest that any rotation or protrusion of an anterior tooth, Class II division 1 or 2 malocclusion, Class III reverse overjets, asymmetries or posterior crossbites, diastemas between maxillary central incisors, ectopically erupted canines, missing teeth (particularly posterior teeth), and tooth length compromise the embouchure and adversely affect a musician playing a brass instrument.

However, little information[21,31] is available concerning malocclusion and quality of trumpet performance. This information could be influential in determining the need for orthodontics in young potential musicians. Since this information might be helpful also to a music teacher in selecting the type of wind instrument with which a young potential player might have the most success, the purpose of this prospective study was to determine whether there is an association between the quality of trumpet performance and dental malocclusion of university trumpet students.

MATERIALS AND METHODS

In this part of a larger prospective study[32] approved by institutional review boards of multiple universities (University of Cincinnati, Indiana University, Indiana State University, Ball State University, University of Louisville, Northern Kentucky University, University of Indianapolis, Wright State University, Butler University, Miami University, and Bowling Green State University), 70 trumpet students (54 male, 16 female; mean age 22.2 $\pm$ 3.8 years, range 20–38.9 years) from 11 universities consented to participate in the study. Although more than 100 students originally made appointments for study consent and participation, only 70 students kept their appointments despite repeated attempts to reappoint. Following completion of a survey concerning dental history and trumpet playing habits, the students were asked to play a scripted performance skills test of flexibility, articulation, range, and endurance exercises using their own instrument to maximize familiarity with the instrument. Each student played the exercises in the same soundproof music practice room while being audio and video recorded. Flexibility was evaluated using three exercises (A, B, and C) (Table 1). The speed (tempo) was measured using a metronome program on

Figure 1. CBCT showing measures for (a) overjet, (b) overbite, and (c) interincisor inclination.

a laptop computer. Articulation evaluated different tongue movements, ie, single tongue, double tongue, triple tongue, and flutter tongue, using four exercises (A, B, C, and D). Range was measured by determining the maximum number of semitones over the note C5 that could be reached. Endurance was determined by timing the maximum continuous play while keeping the notes above a specific sound level. Sound level was controlled using a decibel meter (RadioShack Sound Level Meter: Radio Shack Corporation; Fort Worth, Tex) placed 19 inches from the bell of the trumpet. A few students could not perform all tests, resulting in lower numbers for some tests. An experienced music teacher-investigator evaluated all performances.

A three-dimensional cone-beam computerized tomography scan (3D CBCT) was taken of each student the same day as the skills test. Since the 3D CBCT was available for another part of the study and the CBCT also allowed skeletal and dental structures to be measured, alginate impressions of the dental arches were not taken, thus, minimizing time, cost, and study personnel. Following reliability studies, various parameters of occlusion (overjet [Figure 1a], overbite [Figure 1b], interincisor inclination [Figure 1c], molar [Figure 2] and canine inclination, degree of anterior tooth irregularity—Little's index [Figure 3a], interincisal rotation of the maxillary centrals [Figure 3b], diastema [Figure 3c], maxillary and mandibular intermolar and intercanine widths [Figure 3d]) of all dentitions were measured on the 3D CBCT by one investigator experienced using Dolphin 3D Imaging Software (Chatsworth, Calif.). Arch widths were measured from canine cusp tip to the contralateral canine cusp tip and between the mesiobuccal cusp tips of the contralateral maxillary and mandibular first molars.

Figure 2. CBCT showing measures for molar inclinations.

Reliability Studies

Prior to measures of the 3D CBCTs of each subject, reliability studies were performed on 10 3D CBCTs of subjects not in the study. Each dental parameter was measured twice with an interval of 1 week between each set of measures.

Statistics

Reliability was tested using intraclass correlations. Descriptive statistics (means, standard deviations) were

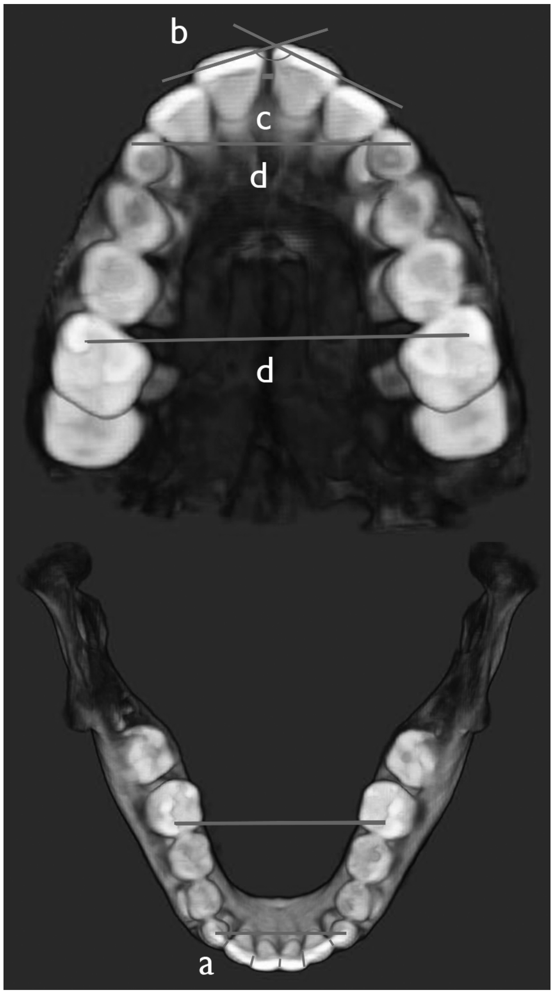

Figure 3. CBCT showing measures of (a) mandibular Little's index (degree of anterior tooth irregularity), (b) interincisal rotation of maxillary centrals, (c) diastema, and (d) intermolar and intercanine widths.

developed. Nonparametric correlations (Spearman) were used because of the lack of normal distribution of the data. Spearman correlation was used to test for significant associations between dental measures and performance skills, accepting $P < .05$ as significant. Although a power analysis was performed prior to the study and more than 100 trumpet students signed for appointments for consenting and participation, only 70 students participated in the study. Therefore, a post-study power calculation was conducted. Because there were randomly missing data points, with sample sizes ranging from 61 to 70 depending on the pair of variables examined, the study had 80% to 85% power to detect a correlation coefficient of 0.35, assuming two-sided tests were conducted at a 5% significance level.

RESULTS

The reliability for all dental measures exceeded $r = .94$, indicating excellent reliability. Descriptive statistics (Tables 2 and 3) of the trumpet performance skills and the dental and occlusal parameters were developed. Several trumpet performance skills (Table 4) significantly correlated, although negatively and weakly, with dental measures, eg, Little's index of irregularity, maxillary central incisor rotation, and incisor angulation. Most arch widths correlated positively with various trumpet skills.

DISCUSSION

The results of this prospective study show that orthodontic problems are associated with trumpet performance of young musicians who played for numerous years. Although many studies[26] have shown that the malocclusion of trumpet players is quite similar to other wind instrument players and to nonplayers, few address possible associations of malocclusion with the quality of trumpet performance by a group of experienced but relatively young trumpet players. However, not all parameters of malocclusion are associated with trumpet performance.

Although common lore among trumpeters suggests that dental parameters such as overbite, overjet, diastema, inclinations of the canines or molars, and molar relationships would affect trumpet performance, our data do not confirm this. The lack of correlation between diastema size and trumpet performance might be explained by the small number (5) of players with diastemas.

As incisor malalignment (Little's index of irregularity) increases, various measures of flexibility and articulation skills decrease. This could be explained by the lingual pressure of the trumpet causing pain when a sensitive lip is pushed against a protruding incisor. Although this might be expected to occur more so in the maxillary incisor region because of the recommended positioning of the trumpet mouthpiece, most of the significant findings are associated with the mandibular teeth. Some trumpeters, however, place their mouthpiece equally upon the lips or even more so on the lower lips.[12] O'Brien[7] suggests that if pressure is placed on the lips, it should be experienced primarily on the lower lip.

Although some trumpet teachers suggest that the trumpeter should not apply pressure against the lips while playing, application of pressure is well documented. Adolescent trumpet students with at least 1year of experience exerted more pressure on an intraoral maxillary lip bumper with embedded pressure transducers[3] when playing C-major scale than did reed instrument or flute students, and this pressure was significantly greater than pressure exerted during other normal activities. O'Brien[7] recognized that young musicians had significant mouthpiece imprints on their

Table 2. Descriptive Statistics of Trumpet Skills and Dental Parameters of Trumpet Students

Trumpet Skills	Mean ± SD	95% Confidence Intervals, Min, Max
Flexibility exercise A, beats/min	113.4 ± 43.8	103.0, 123.9
Flexibility exercise B, beats/min	95.1 ± 22.9	89.7, 100.6
Flexibility exercise C, beats/min	122.8 ± 31.7	115.2, 130.3
Articulation exercise A, beats/min	128.4 ± 14.0	125.0, 131.7
Articulation exercise B, beats/min	196.6 ± 34.9	188.2, 205.0
Articulation exercise C, beats/min	105.9 ± 17.4	101.7, 110.1
Articulation exercise D – high range, beats/min	15.8 ± 4.5	14.6, 17.0
Range – high, half steps	21.3 ± 2.7	20.7, 21.9
Endurance, s	108.7 ± 96.9	85.6, 131.8
Dental Parameters	**Mean ± SD**	**95% Confidence Intervals, Min, Max**
Overjet, mm	2.5 ± 1.4	2.2, 2.9
Overbite, mm	2.3 ± 1.9	1.9, 2.7
Incisor inclination, degrees	125.8 ± 10.6	123.2, 128.8
Diastema, mm	0.03 ± .4	−.1, .13
Maxillary central incisor rotation, degrees	154.2 ± 11.0	151.6, 156.8
Maxillary right molar inclination, degrees	122.2 ± 4.9	121.0, 123.4
Maxillary left molar inclination, degrees	120.5 ± 5.9	119.1, 121.9
Maxillary right canine inclination, degrees	98.2 ± 6.6	96.6, 99.8
Maxillary left canine inclination, degrees	98.4 ± 5.7	97.1, 99.8
Little's index, maxilla, mm	3.3 ± 4.3	2.3, 4.4
Little's index, mandible, mm	4.2 ± 3.9	3.2, 5.1
Maxillary intermolar width, mm	49.1 ± 3.4	48.3, 50.0
Maxillary intercanine width, mm	26.6 ± 2.9	33.4, 34.6
Mandibular intermolar width, mm	44.8 ± 2.9	44.1, 45.4
Mandibular intercanine width, mm	26.6 ± 2.9	25.9, 27.3

lips after short periods of practice, suggesting that the young musicians had exerted pressure on their lips. Fuhrimann et al.[15] confirmed that professional trumpeters exert considerably more pressure on the upper lip during playing as compared with other normal functions. The amount of practice can influence the amount of pressure on the embouchure and serious players practice much longer than amateur players.[18,19] However, highly proficient trumpet musicians applied significantly less force than medium proficient players, and classical trumpet players appeared to exert less force than popular music trumpet players in the high register.[16] Borchers et al.[17] utilized a novel intraoral appliance with multiple strain gauges that showed much larger lingual forces during trumpet playing as compared with playing a French horn, tenor horn, or tuba. Playing of each small cup-shaped brass instrument caused lingual displacement of maxillary incisors. The force and tooth deflection increased more with ascending scale than with intensity of playing, confirming the results of Barbenel et al.[16] Thus, lingual pressure during trumpet playing is well established.

Incisor inclination is negatively associated with articulation. More pressure is placed on the lips while playing in the higher range[17] than in the lower range, possibly causing more lip irritation with proclined incisors than with upright incisors. The rotation of the maxillary central incisors to each other and their negative relationship with performance is an enigma, however. The more aligned maxillary central incisors are to each other, the poorer the flexibility scores. This might be due to a greater amount of contact between the lips and the maxillary teeth when they are aligned and proclined, potentially preventing the lips from moving freely and reducing flexibility. The weak association could be explained by only 10% of the subjects having a Class II molar occlusion. The weakness of this association might confirm the lack of correlation between the maxillary anterior irregularity and performance skills.

Although literature frequently places the blame for performance on the effect of the anterior teeth on the embouchure, not as much information is available on

Table 3. Descriptive statistics of Occlusal Parameters of Trumpet Students

Occlusal Parameter	N (%)
Right molar classification	
Class I	54 (77%)
Class II	7 (10%)
Class III	9 (13%)
Left molar classification	
Class I	55 (79%)
Class II	6 (9%)
Class III	9 (13%)

Table 4. Spearman Correlation (*r*) of Dental Parameters to Trumpet Skills

	Correlation Coefficients (*r*)								
	Flexibility			Articulation					
Dental Parameters Exercise	A n = 70	B n = 70	C n = 70	A n = 70	B n = 69	C n = 69	D High Range n = 61	Range High n = 70	Endurance n = 70
Overjet	.00	.10	−.02	.09	.03	.08	.01	−.02	.18
Overbite	.09	.08	.12	.12	.15	.13	.11	.16	.10
Incisor inclination	.02	.01	−.04	−.07	.04	.04	−.29*	.04	−.06
Mid diastema	.04	.15	.13	−.01	−.06	−.07	−.03	.10	−.09
Maxillary central incisor rotation	−.24*	−.32*	−.12	−.18	−.14	−.10	−.13	.01	−.09
Right molar inclination - maxillary	.00	−.15	.00	.07	−.06	−.13	.14	.14	.14
Left molar inclination - mandibular	−.04	−.14	−.01	.00	.03	−.12	.18	.17	.01
Right canine inclination - maxillary	.03	−.02	.09	−.08	.04	−.06	.15	.04	.01
Left canine inclination - maxillary	−.13	−.13	.08	−.06	−.01	.05	.04	.08	.05
Little's index - maxillary	−.17	−.07	−.14	−.12	−.26*	−.11	−.13	−.23	−.14
Little's index - mandibular	−.25*	−.06	−.26*	−.14	−.28*	−.16	−.05	−.12	−.12
Maxillary intercanine width	.06	−.07	.07	.05	.08	.08	.26*	.08	.15
Maxillary intermolar width	.15	.17	.17	.06	.13	.19	.31*	.03	.08
Mandibular intercanine width	−.03	−.05	−.01	−.01	−.02	.01	.06	.08	.02
Mandibular intermolar width	.14	.25*	.15	.08	.18	.25*	.49*	.20	.10
Right molar classification	−.02	−.11	−.08	.01	.01	−.16	−.04	−.01	−.12
Left molar classification	.02	−.17	−.09	.07	.11	−.11	−.12	−.13	−.04

* Spearman correlation; $P \leq .05$ level (2-tailed).

the effect of the tongue on trumpet playing. For example, articulation is a performance skill that requires tongue movement and could be influenced by the position of the maxillary or mandibular incisors. Single tonguing requires the player to move the tongue back and forth either against the lingual of the maxillary incisors making the sound "ta" or against the incisal edge of the maxillary incisors making the sound "tha." Double tonguing includes touching the posterior tongue to the roof of the mouth to produce the sound "ka" after the touch of the tongue to the maxillary incisors. Triple tonguing adds an additional sound between the two used for double tonguing by making a sound similar to "da" by rolling the portion of the tongue that is about 1 cm posterior from the tip to the roof of the mouth. Flutter tonguing, a technique requiring a high degree of tongue movement, showed an association with incisor inclination. A trumpet player needs sufficient oral space to allow tongue movement.[9] This is confirmed by the positive association between maxillary and mandibular molar arch width and maxillary canine arch width and such exercises as triple tongue movement and flexibility. However, as the tongue moves upward to touch the maxillary incisors, it does not appear to be influenced by mandibular canine arch width, possibly because the mandible moves downward.

Dedicated trumpet players probably compensate or adapt to metabolic or anatomic differences through practice.[30] Professional flautists, for example, can regulate their mouth pressures quite differently from each other but still produce music indistinguishable from each other.[11] Brass musicians appear to compensate for large overjets[22,25] by learning to slide their mandibles forward.[25] Although commitment to professional playing varies, university students have practiced playing their trumpets for many years. However, this study shows that total compensation probably does not occur and that dental anatomic factors influence the quality of trumpet playing after years of practice as noted in these university students. Prospective, long-term studies are recommended to determine if the trumpet performance of adolescent musicians is associated with malocclusion and, if so, how it changes with time, practice, and the type of music played. Future studies should also examine the relationship of malocclusion with other wind instrument performance. Recommendations to trumpet players would be to maximize their performance by correcting as early as possible malocclusion that is shown to be correlated with poor music performance.

CONCLUSION

- Although many studies[22,26] show that the malocclusion of trumpet players is quite similar to that of other wind instrument players and to the malocclusion of controls, this is the first study to show the association of specific malocclusions with the quality of trumpet performance with a group of experienced young trumpet players.

ACKNOWLEDGMENTS

Appreciation is expressed for the subjects, many of whom traveled 2 to 3 hours one way to participate, and to the staff who helped with patient registration. Indiana University-Purdue University 3D Imaging of the Craniofacial Complex Center; Jarabak Professorship; University of Cincinnati University Research Council; University of Cincinnati College-Conservatory of Music Dean's Fund; Anadolu University.

REFERENCES

1. Strayer ER. Musical instruments as an aid in the treatment of muscle defects and perversions. *Angle Orthod*. 1939;9:18–27.
2. Parker JH. The Alameda instrumentalist study. *Am J Orthod*. 1957;43:399–415.
3. Engelmann JA. Measurement of perioral pressures during playing of musical wind instruments. *Am J Orthod*. 1965;51:856–864.
4. Kessler HE. Look for harmony: musical wind instruments and dental development. *Dent Surv*. 1965;41:47–49.
5. Porter MM. Dental problems in wind instrument playing. *Br Dent J*. 1967;123:489–493.
6. Herman E. Dental considerations in the playing of musical instruments. *J Am Dent Assoc*. 1974;89:611–619.
7. O'Brien M. Orthodontic considerations in selecting wind instruments. *J Gen Orthod*. 1993;4:11–13.
8. Weisner G, Balbach D, Wilson M. Orthodontics and wind instrument performance. Paper presented at the Music Educators Conference; 1974; Vienna, Va.
9. Prensky HD, Shapiro GI, Silverman SI. Dental diagnosis and treatment of musicians. *Spec Care Dentist*. 1986;6:198–202.
10. Porter MM. Dental aspects of orchestral wind instrument playing with special reference to the "embouchure." *Br Dent J*. 1952;93:66.
11. Cossette I, Sliwinski P, Macklem PT. Respiratory parameters during professional flute playing. *Respir Physiol*. 2000;121:33–44.
12. Telfer SW. The embouchure: hazards and aids for brass wind instrument players. *Dent Tech*. 1983;36:16–21.
13. StudyMusicOnline. Embouchure misconceptions—five myths about brass embouchures. Available at: http://www.youtube.com/watch?v=uc4jS2-tF8s. Accessed May 5, 2014.
14. Wilktone, The three basic embouchure types. Available at: http://www.wilktone.com/?p=92 Accessed May 5, 2014. Archived at WebCite on May 5, 2014 (http://www.webcitation.org/6PLj57eEA)
15. Fuhrimann S, Shüpbach A, Thürer V, Ingervall B. Natural lip function in wind instrument players. *Eur J Orthod*. 1987;9:216–223.
16. Barbenel JC, Kenny P, Davies JB. Mouthpiece forces produced while playing the trumpet. *J Biomech*. 1988;21:417–424.
17. Borchers L, Gebert M, Jung T. Measurement of tooth displacements and mouthpiece forces during brass instrument playing. *Med Eng Phys*. 1995;17:567–570.
18. Bjurstrom N. Orthodontic treatment as a factor in the selection and performance of brass musical instruments. *Mo J Res Mus Educ*. 1973;3:31–57.
19. Yeo DK, Pham TP, Baker J, Porter SA. Specific orofacial problems experienced by musicians. *Aust Dent J*. 2002;47:2–11.
20. Herman E. Influence of musical instruments on tooth position. *Am J Orthod*. 1981;65:145–155.
21. Testa G. *The Effect of Jaw Thrust Instruction on Four Selected Aspects of Trumpet Performance and Overjet of Young Players* [dissertation]. Miami, Fla:University of Miami; 1972.
22. Gualtieri PA. May Johnny or Janie play the clarinet? The Eastman Study: a report on the orthodontic evaluation of college-level and professional musicians who play brass and wood wind instrument. *Am J Orthod*. 1979;76:260–276.
23. Lovius BB, Huggins DG. Orthodontics and the wind instrumentalist. *J Dent*. 1973;2:65–68.
24. Pang A. Relation of music instruments to malocclusion. *J Am Dent Assoc*. 1976;92:565–570.
25. Rindisbacher T, Hirschi U, Ingervall B, Geering A. Little influence on tooth position from playing a wind instrument. *Angle Orthod*. 1989;60:223–228.
26. Grammatopoulos E, White AP, Dhopatkar A. Effects of playing a wind instrument on the occlusion. *Am J Orthod Dentofacial Orthop*. 2012;141:135–145.
27. Rodriguez-Lozano FJ, Saez-Yuguero MR, Bermejo-Fenoll A. Orofacial problems in musicians: a review of the literature. *Med Probl Perform Art*. 2011;26:150–156.
28. Nixon GS. Dental problems of the brass-instrumentalist. *Br Dent J*. 1963;115:160–161.
29. Ma HC, Laracuente JM. The influence of playing musical wind instruments on oral tissues. *Gen Dent*. 1979;27:46–50.
30. DiStasio ER. Wind instruments: another look. *J Mass Dent Soc*. 1981;30:152–155.
31. Lamp CJ, Epley FW. Relation of tooth evenness to performance on brass and woodwind musical instruments. *J Am Dent Assoc*. 1935;22:1232–1236.
32. Cilingir HZ. Oral anatomy of a trumpet player: prediction of physical talent. Paper presented at: International Women's Brass Conference June 6, 2012. Kalamazoo, Mich.