Original Article

The Association Between Relative Bite Force and Lip Pressure

Hsin-Pin Li
Department of General Dentistry, Chang Gung Memorial Hospital, Linkou, Taiwan

Hsiu-Na Lin
Department of General Dentistry, Chang Gung Memorial Hospital, Taipei, Taiwan

Yu-Hwa Pan
Department of General Dentistry, Chang Gung Memorial Hospital, Taipei, Taiwan
Graduate institute of dental and craniofacial science, Chang Gung University, Taoyuan, Taiwan

Yu-Fu Shen
Department of General Dentistry, Chang Gung Memorial Hospital, Linkou, Taiwan

Tsung-Po Tsai
Department of General Dentistry, Chang Gung Memorial Hospital, Linkou, Taiwan

Yi-Fang Huang
Department of General Dentistry, Chang Gung Memorial Hospital, Linkou, Taiwan

Corresponding author:
Dr. Yi-Fang Huang
Department of General Dentistry, Chang Gung Memorial Hospital
No.5, Fuxing St., Guishan Township, Taoyuan County 33305, Taiwan, R.O.C.
Tel：+886-3-3281-200 ext. 8323
Fax: +8863-3-3278-928
E-mail：yifang0324@gmail.com

Abstract

Objective

The aim of this study was to determine the correlations between perioral soft tissue performance and masticatory function.

Material and methods

Fourteen subjects aged 23 to 40 years old (mean: 29.4 years) were enrolled in this study. All of the participants had normal oral anatomic structures and stable posterior tooth support. The relative bite force (%) compared to the maximal bite force in the right and left arches was measured using the T-Scan III® system. The lip pressure (kPa) over the right and left cheeks was evaluated by the Iowa Oral Performance Instrument (IOPI®) Pro system and its bulbs. The data were presented as the mean ± standard deviation (SD) and compared using the paired t test.

Results

The mean relative bite force of the subjects was 51.2±21.7 % (mean ± SD) on the left side and 48.4±21.7 % (mean ± SD) on the right side. The mean lip pressures on the left side and right side were 24.9 ±5.2 kPa (mean ± SD) and 23.9 ±4.2 kPa (mean ± SD), respectively. There were significant correlations between the relative bite force and lip pressure on both the left and right sides ($p<0.01$).

Conclusion

The study results indicated a significant association between relative bite force and lip pressure. In clinical terms, we might thus infer that improved masticatory function would perhaps result in improved lip pressure. Relatedly, it is worth further investigating whether prosthodontic rehabilitation resulting in increased perioral soft tissue strength is correlated with improvements to the sucking or swallowing functions.

Key words: lip pressure, relative bite force

Introduction

According to the equilibrium theory of tooth position, the forces exerted by the lips, cheeks, and tongue all affect the positions of the teeth. Relatedly, previous studies have shown that the most important environmental factors affecting tooth position are the pressures exerted by the lips and cheeks[1]. The force generated by perioral soft tissues plays a role in guiding tooth eruption and maintaining dental arch form and stability[2]. Therefore, lip pressure is closely related to the state of occlusion, and may even have a significant effect on oropharyngeal function.

Masticatory function impairment can adversely affect quality of life[3]. Sufficient masticatory function, in contrast, is considered to contribute substantially to general health[4]. Evaluating the chewing performance is one common way to obtain an overall measurement of masticatory function. Masticatory performance would be influenced by a number of factors, including the teeth, masticatory muscle strength, jaw movements, and maximum bite force[3]. The maximum bite force is directly related to masticatory performance; it can not only explain over 60% of the variance in masticatory efficiency but also 72% of the variation in masticatory performance among children and adults[3-6].

Oral functions including swallowing and chewing are accomplished by complex and coordinated neuromuscular actions. However, few studies have investigated the association between perioral soft tissue and bite force, and there is some controversy regarding whether strong lip tension has any impact on masticatory performance. At the same time, it is important for prosthodontists to know if high lip pressure affects denture stability or has any other effects that could influence prosthodontic treatment planning. Moreover, it would also be valuable to know whether increasing the bite force can effectively increase the tension of the muscles around the oral cavity in a way that, in turn, improves the swallowing function. With these issued in mind, we sought in this study to measure the lip pressure and relative bite force of the study participants in order to determine the correlations between the tension of the perioral soft tissue and masticatory function.

Materials and Methods

Fourteen subjects including five men and nine women were analyzed in this study. Their ages ranged from 23 to 40 years old, and their mean age was 29.4 years. All of the subjects had normal oral anatomic structures and stable posterior tooth support; their occlusal classification was limited to Angle's Class I occlusion. In addition, none of them had any neuromuscular disorders or dysphagia. Their consciousness was clear and they could cooperate as necessary in order to complete the entire study. Furthermore, they were all enrolled in the study only after they were well informed of its details and had signed a consent form.

The relative bite force of each subject was measured using the digital occlusion analysis T-Scan III® system (Fig. 1), which utilizes a thin-film interface

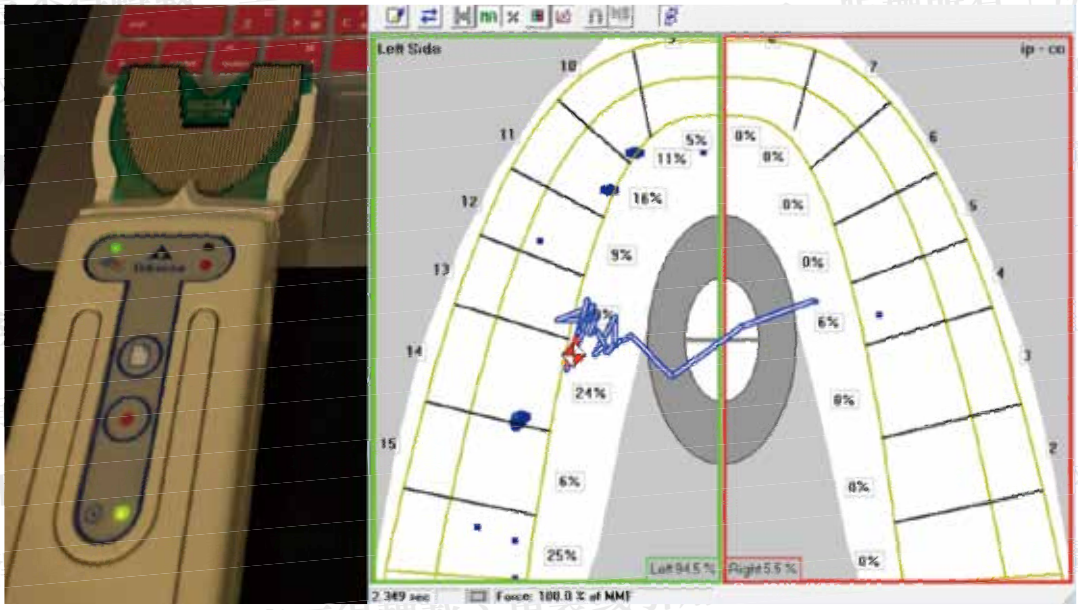

Fig. 1. T-Scan III® is a digital occlusal analysis system consisting of a patented sensor, ergonomic handpiece, and proprietary software that reveals the level and timing of force on individual teeth and the stability of the patient' s bite

pressure mapping sensor to detect the relative bite force. Each participant was invited to sit in a relaxed and upright position during the relative bite force evaluation and trained to firmly bite the sensor until maximal intercuspation lasting one to three seconds. Once the given participant was familiar with operation of the instrument, he or she was instructed to bite so as to indicate the centric occlusion. The percentages (%) of the relative bite force distribution to the bilateral arches compared to maximal bite force were calculated.

The Iowa Oral Performance Instrument (IOPI®) Pro system (Fig. 2), a new type of pressure measuring instrument, was utilized to evaluate the lip pressure (kPa) over the right side and left side. For this evaluation, the patient sat upright in the chair, the IOPI bulb was placed between the lips, and the patient squeezed the IOPI® bulb against the buccal surface of the teeth by pursing the lips as hard as possible. The lip pressure measurement was performed five times on both the left and right sides.

This study separately analyzed the data for the left side and right side in order to explore the correlation between lip pressure and relative bite force. The data were presented as the mean ± standard deviation (SD) and compared with using the paired t test. The IBM SPSS Statistics Version 20.0 was utilized for statistical analysis, and a P <0.01 was considered to indicate a statistically significant difference.

Results

The mean relative bite forces of the 14 subjects were 51.2±21.7 % (mean ± SD) on the left side and 48.4±21.7 % (mean ± SD) on the right side. (Table1) The mean lip pressures on the left side and right side were 24.9 ±5.2 kPa (mean ± SD) and 23.9 ±4.2 kPa (mean ± SD), respectively (Table 1). We used the paired t test to determine the correlations between the relative bite force and lip pressure, and there were significant correlations on both the left and right sides (p<0.01) (Table 1).

Fig. 2. The Iowa Oral Performance Instruments (IOPI®) Pro and its bulb

Discussion

Many factors influence masticatory performance, including the perioral musculature, the positions of the teeth, the jaw movements, the occlusion pattern, the occlusal contact area, and the bite force[3,5,6]. Meanwhile, impaired masticatory function can have significant negative effects on an individual's quality of life. The functional harmony and balance of the muscles converging in the lip and cheek area are important in the growth and development of the dento-alveolar morphology and craniofacial region[7]. The force generated by perioral soft tissues plays an important role in guiding tooth eruption and maintaining dental arch form and stability[2]. Therefore, lip pressure is not only closely

Table 1. Comparison between relative bite force and lip pressure (n=14)

	Relative bite force (%)		Lip pressure (kPa)			
	Mean	SD	Mean	SD	95% CI	P
Right side	48.37	21.66	23.91	4.16	36.59 (5.62 to 12.31)	.001**
Left side	51.18	21.72	24.90	5.21	40.16 (6.42 to 12.40)	.001**

Paired t test **P<0.05

SD indicates standard deviation; CI indicates confidence interval

related to the state of occlusion but also affects the abilities of feeding, eating, speech, saliva control, and the articulation of labial consonants[8,9]. Moreover, the results of this study preliminarily indicated a significant association between lip pressure and relative bite force ($P < 0.001$) (Table 1). This finding was consistent with those of a previous study showing that maximum lip force and maximum bite force significantly predict masticatory performance in healthy elderly patients and stroke patients[10] .Another investigation furhter revealed that lip force is also closely related to swallowing capacity; in that study, dysphagia was improved when the lip force was raised and the lip pressure was significantly lowered in a patient who had a history of choking on food[11]. In patients with impaired mimic muscles or in denture patients, the lip seems to take over more critical roles and thus might also contribute to the bolus-kneading process[10]. Based on previous research, the lip-closing function might represent the pharyngeal strength involved in swallowing[11,12].

Maximum bite force is an indicator of masticatory function.13 Relatedly, measurements of bite force can provide useful data for evaluations of jaw muscle function and activity[14]. A variety of devices with a diversity of designs and working principles have been used to record bite forces. In this study, the T-Scan III® system, which utilizes an ultra-thin (0.004 inch, 0.1 mm), reusable sensor that is shaped to fit the dental arch, was used to evaluate the relative bite force and occlusal contact area in the intercuspal position and to acquire the associated data[15]. The relative bite forces distributed over the right and left arches were represented in this study as percentages compared to the maximum bite force instead of with actual units of force such as Newtons. Because this research was mainly conducted to explore the relationship between the relative bite force and lip pressure, the unit could be ignored. Besides, the inclusion criteria used for subject selection were strict and included fully intact dentition and no previous history of orthodontic or prosthodontic treatment. Furthermore, this study was designed to compare the relative bite force and lip pressure in individuals in a way that could prevent experimental error resulting from individual differences and thus increase the realism of the results.

In clinical practice, efforts aimed at training the strength of the perioral soft tissue are usually aimed at swallowing function rehabilitation. The results of this study showed that there were significant correlations between the lip pressures and relative bite force on both the left and right sides ($p<0.01$). These results suggest that increasing the lip pressure might not only resolve dysphagia but also improve masticatory function. Moreover, we could infer that measurements of lip pressure can be used as a reference in prosthodontic treatment planning. For example, in clinical practice, patients with stronger lip strength might be expected to benefit more from implant therapy than from being fitted with a removable denture. It is also worth further investigating whether successful prosthodontic rehabilitation can not only increase the bite force but also help in the recovery of other oral functions such as sucking or swallowing. Furthermore, one limitation of this study was that the smile lines of the subjects had to be restricted, so it would be interesting to investigate in the future whether the smile line has any impact on the association between lip pressure and relative bite force. Another hypothesis derived from this investigation is that the clinical training of oral muscle strength could perhaps improve masticatory force in those wearing removable dentures. In fact, given that the results of this study indicated close associations between the different elements of the oral apparatus, including the perioral musculature and dentition, there are a number of related interesting topics that need to be explored in the future.

Conclusion

The results of this study indicated significant correlations between the relative bite force and lip pressure. Clinical training of perioral muscle strength may thus improve the masticatory function, while increasing the relative bite force with prosthodontic rehabilitation might aid in the recovery of oral functions related to lip pressure, such as sucking or swallowing.

Acknowledgement

This study is supported by Chang Gung Memorial Hospital, Linkou (CMRPG3H0371).

References

1. Lapatki BG, Mager AS, Schulte-Moenting J, Jonas IE. The importance of the level of the lip line and resting lip pressure in Class II, Division 2 malocclusion. J Dent Res. 2002;81:323-8.
2. Di Fazio D, Lombardo L, Gracco A, D'Amico P, Siciliani G. Lip pressure at rest and during function in 2 groups of patients with different occlusions. Am J Orthod Dentofacial Orthop. 2011;139:e1-6.
3. Lepley CR, Throckmorton GS, Ceen RF, Buschang PH. Relative contributions of occlusion, maximum bite force, and chewing cycle kinematics to masticatory performance. Am J Orthod Dentofacial Orthop. 2011;139:606-13.
4. Witter DJ, Woda A, Bronkhorst EM, Creugers NH. Clinical interpretation of a masticatory normative indicator analysis of masticatory function in subjects with different occlusal and prosthodontic status. J Dent. 2013;41:443-8.

5. Hatch JP, Shinkai RS, Sakai S, Rugh JD, Paunovich ED. Determinants of masticatory performance in dentate adults. Arch Oral Biol. 2001;46:641-8.
6. Julien KC, Buschang PH, Throckmorton GS, Dechow PC. Normal masticatory performance in young adults and children. Arch Oral Biol. 1996;41:69-75.
7. Tsutsui T, Yoshizawa K, Moroi A, et al. Change in lip closing force in Classes II and III malocclusion before and after sagittal split ramus osteotomy with Le Fort I osteotomy. J Craniomaxillofac Surg. 2017;45:1415-18.
8. Sjogreen L, Lohmander A, Kiliaridis S. Exploring quantitative methods for evaluation of lip function. J Oral Rehabil. 2011;38:410-22.
9. Moverare T, Lohmander A, Hultcrantz M, Sjogreen L. Peripheral facial palsy: Speech, communication and oral motor function. Eur Ann Otorhinolaryngol Head Neck Dis. 2017;134:27-31.
10. Schimmel M, Memedi K, Parga T, Katsoulis J, Muller F. Masticatory Performance and Maximum Bite and Lip Force Depend on the Type of Prosthesis. Int J Prosthodont. 2017;30:565-72.
11. Sakai K, Nakayama E, Tohara H, et al. Diagnostic accuracy of lip force and tongue strength for sarcopenic dysphagia in older inpatients: A cross-sectional observational study. Clin Nutr. 2019;38:303-9.
12. Tamura F, Fukui T, Kikutani T, et al. Lip-closing function of elderly people during ingestion: comparison with young adults. Int J Orofacial Myology. 2009;35:33-43.
13. Koc D, Dogan A, Bek B. Effect of gender, facial dimensions, body mass index and type of functional occlusion on bite force. J Appl Oral Sci. 2011;19:274-9.
14. Koc D, Dogan A, Bek B. Bite force and influential factors on bite force measurements: a literature review. Eur J Dent. 2010;4:223-32.
15. Verma TP, Kumathalli KI, Jain V, Kumar R. Bite Force Recording Devices - A Review. J Clin Diagn Res. 2017;11:ZE01-ZE05.