Int J Clin Exp Med 2018;11(4):3757-3764
www.ijcem.com /ISSN:1940-5901/IJCEM0065403

Original Article

Quantification of clinical parameters in patients with vertical food impaction treated by occlusal adjustment: cone-beam computed tomography analysis

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Received March 9, 2017; Accepted February 10, 2018; Epub April 15, 2018; Published April 30, 2018

Abstract: *Objectives:* This study aimed to determine the effectiveness of occlusal adjustment for vertical food impaction, and evaluate the quantitative standards of vertical food impaction treated by occlusal adjustment. *Methods:* A total of 51 patients who suffered from vertical food impaction without anatomical structure destruction and presented to the Dental Hospital of Shanxi Medical University were selected for this study. These patients were treated by occlusal adjustment and the dental impressions were made before and after treatment. Cone-beam computed tomography (CBCT) was used to scan and measure six clinical parameters, including the length of the interproximal contact area in the food impaction zone, angle of the occlusal buccal-lingual embrasure, and occlusal height and width. *Results:* Therapeutic results were followed up, and the relevance between each parameter and the treatment outcome was investigated through statistical analysis. Results indicated that the length of the interproximal contact and occlusal height significantly increased after adjustment ($P < 0.001$), and the difference in occlusal buccal-lingual embrasure angle before and after treatment was not statistically significant ($P>0.05$). *Conclusions:* The length of the interproximal contact and occlusal height are critical factors for curing vertical food impaction. The best therapeutic effect could be achieved when occlusal height and width measurements reach 1.0-1.6 mm and 0.9-1.2 mm, respectively.

Keywords: Food impaction, quantitive standards, occlusal adjustment, cone-beam computed tomography

Introduction

Food impaction is defined as the forceful wedging of food through occlusal pressure into the interproximal spaces, and characterizes the typical phenomenon that food particles or fibers is embedded in the gap of adjacent teeth during the process of chewing [1, 2]. Frequent food impaction can increase the risk of oral and dental diseases such as halitosis, dental caries, gingivitis, periodontitis, and even tooth loss [3, 4]. According to the different directions of food dregs between teeth, food impaction can be subdivided into three forms: vertical, horizontal and mixing [5]. Clinically, patients who suffer from vertical and mixing food impactions are the key group, accounting for 90.3% of the total cases [6]. Vertical food impaction with anatomical structure destruction can be cured through methods of tooth filling, inlay and crown prosthesis [7-11], while occlusal adjustment is an effective treatment for vertical food impaction without dental anatomical structure destruction [12].

Recently, sequential occlusal adjustment emerged as an effective treatment option for certain kinds of food impaction. The elimination of food impaction was claimed by patients after one or two weeks of follow up, and after six months of follow up. None of the patients reported food impaction after sequential occlusal adjustment, indicating the effectiveness of sequential occlusal adjustment for eliminating

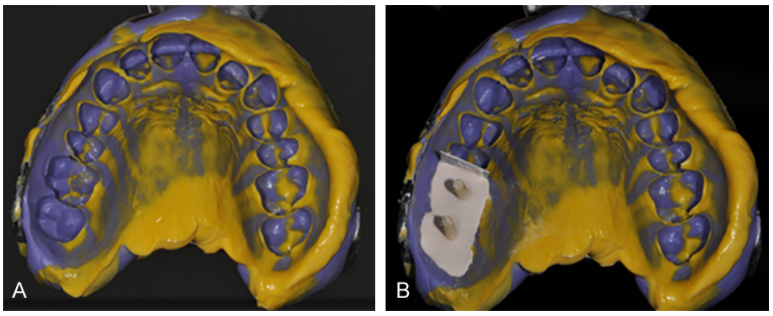

Figure 1. A. Making impressions. B. Perfusing target teeth position by die stone.

Table 1. Food impaction rating scale

Level	1	2	3	4	5	6	7	8	9
Interval	A			B			C		
Patients	Slight food impaction			Affect eating			Serious food impaction		
Feelings	Acceptable			Tolerable			Could not bear		

vertical food impaction with anatomical structure destruction [13]. It has been reported that occlusal adjustment is an effective treatment for food impaction, which does not cause anatomical structure destruction and is performed by acquiring sufficient mesial movement [14]. In addition, occlusal adjustment was performed by using diamond and polishing stones to create buccal and lingual food escape grooves that would allow food to escape buccally and lingually from occlusal surfaces, preventing food impaction [15].

In particular, the means of occlusal adjustment to treat food impaction involves the adjustment of filling cusps, reduction of the interproximal contact area, opening of dental embrasures, and the expansion or reconstruction of a food spillway [15]. Unfortunately, no previous studies have systematically investigated occlusal adjustment for clinical application and further established quantitive standards. This has brought difficulties and unpredictabilities to clinical treatment and practice. In the present study, cone-beam computed tomography (CBCT) was used to measure six parameters in the food impaction zone before and after occlusal adjustment. Compared with previous studies, the present study aimed to investigate the influence of each parameter on the pathogenesis and curative effect of vertical food impaction, and to ultimately provide quantitative standards for clinical treatment.

Materials and methods

Ethic statement

This study was approved by the Ethics Committee of Shanxi Medical University. All experimental protocols and procedures were approved by the Licensing Committee, and performed in accordance with approved guidelines and regulations. All patients were informed that the results of the occlusal adjustment, impression fabrication and CBCT scans would be used in an *in vitro* study. Informed consent was obtained from all subjects.

Study subjects selection

A total of 51 patients who suffered from food impaction and presented to the Dental Hospital of Shanxi Medical University between 2014 and 2015 were selected for this study. Among these patients, 28 patients were male and 23 patients were female; and the age of these patients ranged between 26 and 58 years. These patients were included into the study if they frequently underwent food impaction between the maxillary first molar and second molar, with duration of at least four weeks. In addition, the adjacent teeth in the impacted zone of these patients should be complete without looseness, dentin hypersensitivity and severe wear. Furthermore, the dental interproximal system should be normal without caries. Patients who had their designated impacted zone restored by fillings, patients who have inlays and full crowns, or patients who suffered from buccoversion or linguoversion and uncontrolled periodontitis were excluded from this study.

Clinical treatment

Ultrasonic teeth cleaners were first used for scaling impacted teeth, in order to remove embedded food particles, debris and dental calculus. The maxillary and mandibular dentition was recorded with a silicon-rubber impression (DMG, Germany) before treatment (**Figure 1A**).

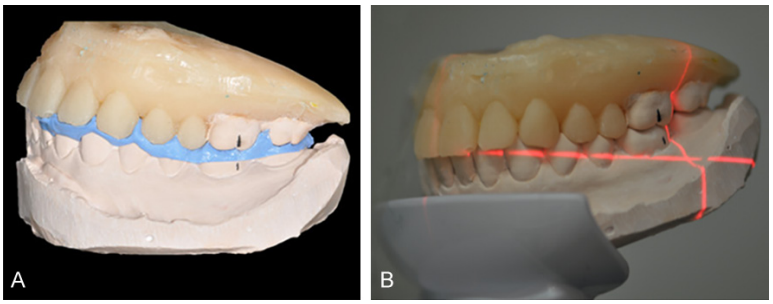

Figure 2. A. Positioned upper lower jaw model. B. Scanning position lines.

Then, the position of the impacted tooth and the other tooth was perfused with die stones (Heraeus, Germany) and self-curing resins (Shanghai New Century Dental Materials Co. Ltd.) (**Figure 1B**). The prepared plaster models were fixed according to the original occlusal relationship.

The extent of food impaction before occlusal adjustment was determined using a table (**Table 1**). Specifically, the feel of patients on the food impaction was divided into three intervals and nine levels, according to the severity of the food impaction.

Then, occlusal adjustment was applied to these patients. A TF-21 diamond bur was used to grind the cusp and marginal ridge of the maxillary first molar and second molar, as well as the paired jaw teeth. The TF-14 diamond bur was employed to prepare a spillway for food and deepen the occlusal embrasure. Furthermore, the occlusal adjustment also expanded the buccal-lingual embrasure angle and reduced the length of the interproximal contact.

The curative effects were evaluated through the difference (d) between the level of food impaction, which the patients selected from **Table 1** before and after treatment. Specifically, $d \geq 5$ indicates that the food impaction symptom was cured, $3 \leq d \leq 4$ indicates that the food impaction symptom improved, and $d \leq 2$ indicates that the treatment was ineffective. After treatment, the grinded teeth should be polished and covered with a desensitizer or fluor protector, in order to prevent tooth sensitivity. Similarly, silicon-rubber impressions and plaster-resin models were made after occlusal adjustment.

Measurement

CBCT (3DX multi image micro-CT, Japan) was used to scan the plaster-resin models. First, the upper lower jaw model was positioned by bite registration material and fixed on the chin holder (**Figure 2A**). Then, the scanning area was fixed with three infrared lights: the horizontal position line was flushed with the incisor edge of the maxillary central incisor, the sagittal position line was aligned with the contact zone of maxillary central incisor, and the coronal position line was leveled with the contact region of the maxillary first molar and second molar (**Figure 2B**). The scanning region was limited to a 30-mm area on each side of the three position lines. Scanning conditions: tube voltage and current was 60 kV and 2 mA, respectively; and scan thickness and layer spacing was 1.0 mm.

Parameter definition

The first layer cross-section that appeared from the occlusion to the gingiva in the horizontal position was the base plane on which the length of the interproximal contact and the buccal-lingual angle were measured: (1) Length of the interproximal contact: the line between adjacent points close to the buccal and lingual orifices, respectively (**Figure 3A**); (2) Buccal-lingual orifice angle: the angle formed with the adjacent point near to the buccal or lingual side, and the food spillway between the maxillary first molar and second molar on the same cross section (**Figure 3B**). Measurements of the occlusal embrasure and occlusal height and width were performed on the coronal plane where the adjacent point firstly appeared: (1) Occlusal embrasure angle: the angle formed with this adjacent point and the food spillway between the maxillary first molar and second molar on the same cross section (**Figure 3C**); (2) Occlusal height: the minimum vertical distance measured from the bottom of the occlusal embrasure on the selected cross-section to the cusp or ridge of the antagonistic teeth (**Figure 3D**); (3) Occlusal width: the horizontal distance of the occlusal embrasure bottom after occlusal adjustment (**Figure 3E**). All data mentioned above were completed by the same

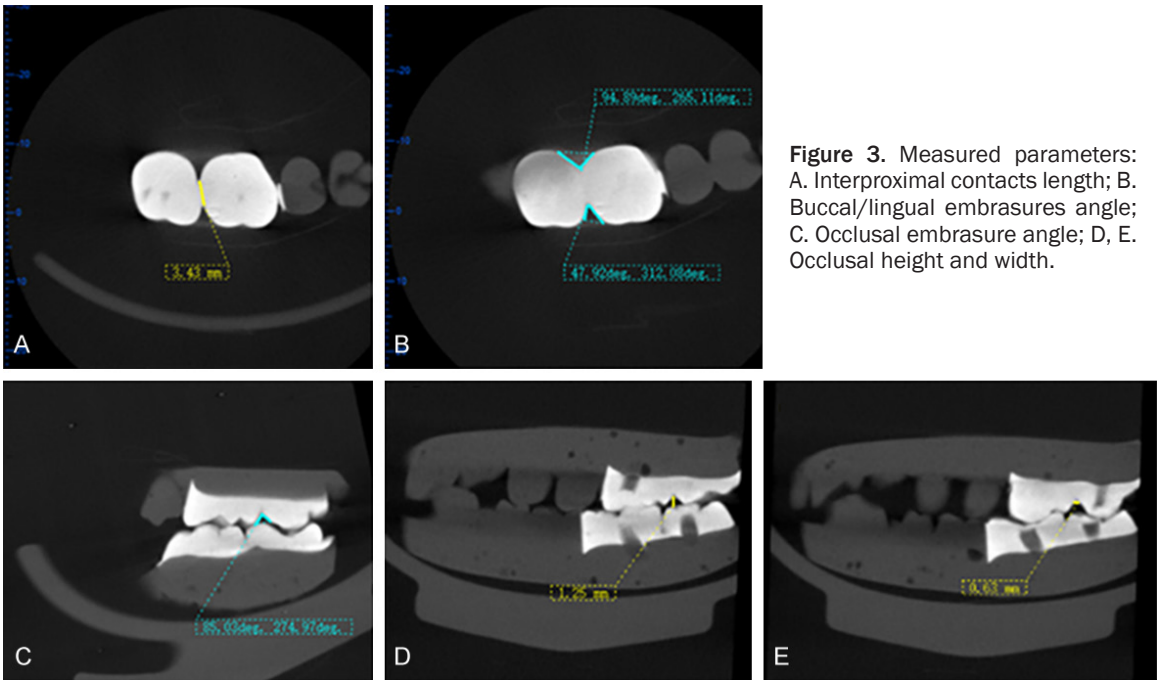

Figure 3. Measured parameters: A. Interproximal contacts length; B. Buccal/lingual embrasures angle; C. Occlusal embrasure angle; D, E. Occlusal height and width.

Table 2. Comparisons of the parameters before and after treament (median (interquartile range))

Parameter	Case number	Before treatment	After treatment	Z	*P*
Interproximal contacts length (mm)	51	4.190±1.56	3.630±1.695	-0.516	< 0.001*
The angle of buccal embrasure (°)	51	54.64±19.26	58.24±14.51	-0.66	0.948
The angle of lingual embrasure (°)	51	52.25±13.95	51.34±14.16	-0.019	0.985
The angle of occlusal embrasure (°)	51	59.75±42.34	69.20±20.74	-4.181	0.606
Occlusal height (mm)	51	0.670±0.213	1.043±0.376	-5.785	< 0.001*

Note: According to the inspection level of α=0.05, "*" represents statistically significant difference before and after treatment.

Table 3. Comparisons of parameters from the view of curative effects (median (interquartile range))

Parameter	Treatment effects		Z	*P*
	Improved (n=14)	Cured (n=37)		
Interproximal contacts length (mm)	4.26±1.61	3.51±1.51	-1.46	0.144*
The angle of buccal embrasure (°)	49.64±13.62	59.30±14.51	-0.676	0.499
The angle of lingual embrasure (°)	58.24±19.28	51.21±11.1	-1.352	0.276
The angle of occlusal embrasure (°)	67.12±5.11	73.45±20.74	-1.204	0.329
Occlusal height (mm)	0.960±0.170	1.003±0.389	-1.291	0.197*
Occlusal width (mm)	0.712±0.250	0.793±0.250	-1.987	0.047**

Note: "**" means P < 0.05, "*" means P < 0.25.

person. For each sample, at least three measurements were carried out, and the average values were reported.

Statistical analysis

Statistical comparisons were performed using SPSS 16.0 software. Parameters before and after occlusal adjustment were compared using the Wilcoxon paired test. Parameters viewed from different curative effects were compared using the Wilcoxon rank sum test. Chi-square test was used to analyze the difference between group and logistic regression analysis was utilized to determine the relationship between certain key parameters and treatment outcomes after occlusal adjustment. When Chi-square test was used to test the difference

Table 4. Comparisons of curative effects resulted from different occlusal height (%)

Group	Treatment effects		Summation	χ^2	*P*
	Improved	Cured			
[0.6-1.0) mm	10	15	25	7.095	0.020*
[1.0-1.6) mm	2	20	22		
[1.6-1.8) mm	2	2	4		
Summation	14	37	51		

Note: "*" means P < 0.05.

Table 5. The paired comparisons of various occlusal height groups (%)

Group	Treatment effects		Summation	χ^2	*P*
	Improved	Cured			
[0.6-1.0) mm	10	15	25	5.880	0.015*
[1.0-1.6) mm	2	20	22		
Summation	12	35	47		
[0.6-1.0) mm	10	15	25	0.000	1.000
[1.6-1.8) mm	2	2	4		
Summation	12	17	29		
[1.0-1.6) mm	2	20	22		0.099
[1.6-1.8) mm	2	2	4		
Summation	4	22	26		

Note: "*" means P < 0.0168.

between three groups, the *P* value was corrected and 0.05/3 was the new inspection which means that P < 0.0168 indicated statistical significance. For more free variables entering the regression equation, more than 80% power of test was acceptable which means P < 0.20. Unless stated otherwise, statistical significance was set at a *P* value of < 0.05.

Results

Comparisons of the parameters before and after occlusal adjustment

As shown in **Table 2**, the difference in occlusal buccal-lingual embrasure angle was not statistically significant before and after treatment (*P*>0.05). This indicates that there was no obvious change in these three parameters. The length of the interproximal contact and occlusal height significantly increased after adjustment (*P* < 0.001).

Comparisons of various parameters in view of different curative effects

The results presented in **Table 3** revealed that the difference in occlusal width was statistically significant from the perspective of treatment outcomes (*P* < 0.05). Occlusal width increased in the cured group, compared with the improved group.

Comparison of curative effects that resulted from different occlusal height

Adjustment of the occlusal height could lead to various therapeutic results, and the difference in occlusal height between these groups was statistically significant (**Table 4**, *P* < 0.05).

Table 5 shows the paired comparisons of various occlusal height groups. The 1.0-1.6 mm group revealed a significant improvement in curative effect, compared with the 0.6-1.0 mm group. However, the difference in treatment outcomes that resulted from the 0.6-1.0 mm and 1.6-1.8 mm groups, or 1.0-1.6 mm and 1.6-1.8 mm groups were not statistically significant.

Comparison of curative effects that resulted from different occlusal width

Occlusal width is critically important for solving food impaction problems. As shown in **Table 6**, the difference in occlusal width among groups was statistically significant (*P* < 0.05). Treatment effects in the 0.4-0.6 mm group was inferior to that of the 0.9-1.2 mm group, and the results were statistically significant (**Table 7**, *P* < 0.0168). However, the difference in curative effects between the 0.4-0.6 mm and 0.6-0.9 mm groups or 0.6-0.9 mm and 0.9-1.2 mm groups was not statistically significant (*P*>0.0168).

The relationship between key parameters and treatment outcomes after occlusal adjustment

According to logistic regression analysis results (**Table 8**), the difference in the length of the interproximal contact and occlusal height was statistically significant in terms of evaluating the therapeutic effects. Quantitatively, the possibility of healing would decrease by 0.562 times for every 1 mm increase in length of the interproximal contact, while patients with an occlusal height of 1.0-1.6 mm might achieve a cure rate 10.489 times higher than that in the 1.6-1.8 mm group.

Table 6. Comparisons of curative effects resulted from different occlusal width (%)

Group	Treatment effects		Summation	χ^2	*P*
	Improved	Cured			
[0.4-0.6) mm	5	2	7	7.319	0.02*
[0.6-0.9) mm	7	22	29		
[0.9-1.2) mm	2	13	15		
Summation	14	37	51		

Note: "*" means P < 0.05.

Table 7. The paired comparisons of various occlusal width groups (%)

Group	Treatment effects		Summation	χ^2	*P*
	Improved	Cured			
[0.4-0.6) mm	5	2	7	3.746	0.053
[0.6-0.9) mm	7	22	29		
Summation	12	24	36		
[0.6-0.9) mm	7	22	29	0.201	0.654
[0.9-1.2) mm	2	13	15		
Summation	9	35	44		
[0.4-0.6) mm	5	2	7		0.014*
[0.9-1.2) mm	2	13	15		
Summation	7	15	22		

Note: "*" means P < 0.0168.

Discussion

Vertical food impaction is a common and frequently-occurring disease in clinic [16], and refers to the phenomenon that food is pushed into the tooth clearance from the vertical direction by external forces during the chewing process [5]. Clinically, occlusal adjustment is an effective tool for vertical food impaction, which includes grinding the filling cusps and occlusal marginal ridge, expanding embrasures, reconstructing the spillway of food [13], and adjusting the bite force of the impacted teeth [17]. However, commonly used treatments had never attracted enough academic attention, and had not been systematically and quantitatively investigated. In this study, food impaction was treated by occlusal adjustment, and relevant parameters were studied quantitatively for further guidance in more accurate clinical practices.

In the present study, patients who suffered from food impaction between the maxillary first molar and second molar were selected. The reason for this choice was that food impaction was prone to occurring in the clearance of the first molar and second molar, and symptoms that occur in the maxilla and under jaw are almost identical.

Multi-factor logistic regression analysis results demonstrated that the change in occlusal height played an important role in achieving positive treatment effects. Clinical observation revealed that occlusal height in the food impaction area was small and even approached to zero, which led to deficiency of the food spillway. Consequently, it was believed that adjusting the teeth cusp and deepening the occlusal embrasure were effective methods to treat food impaction. As it might be expected, clinical trials have proven that the vertical height between the teeth cusp and ridge increased after precise adjustment, and the obtained clearance formed a spillway for food, which was advantageous in alleviating the symptoms of vertical food impaction.

The data presented in **Table 3** indicates that there was some correlation between occlusal width and its curative effects, but no evidence revealed that the occlusal width was an important factor to evaluate treatment outcomes by multi-factor logistic regression analysis. The reason for such result is that the measurement of the occlusal width was established on the occlusal height after treatment. Actually, it was more appropriate to observe the width as an assistant indicator to affect therapeutic efficacy. Nonetheless, the research of this parameter was necessary, because it can provide a quantitative standard correlated to the width for better treatment results.

In general, occlusal height and width provides synergistic effects for treating food impaction. On the basis of statistical analysis, the best therapeutic effect could be achieved when occlusal height and width reaches 1.0-1.6 mm and 0.9-1.2 mm, respectively.

In addition to occlusal height, there was evidence that the length of the interproximal contact was also critically important to gain good curative effects (**Table 8**). According to logistic

Table 8. The results of logistic regression analysis

Independent variable	Regression coefficient	Standard error	Wald X^2	P	OR	OR 95% CI
Interproximal contacts length	-0.825	0.432	3.651	0.056*	0.438	(0.188, 1.021)
Occlusal width (0.4-0.6 vs. 0.9-1.2)	-0.973	1.225	0.631	0.378	0.378	(0.034, 4.167)
Occlusal width (0.6-0.9 vs. 0.9-1.2)	-0.612	1.026	0.356	0.542	0.542	(0.073, 4.052)
Occlusal height (0.6-1.0 vs. 1.6-1.8)	-0.324	1.503	0.047	0.829	0.732	(0.038, 13.763)
Occlusal height (1.0-1.6 vs. 1.6-1.8)	2.350	1.708	1.895	0.169*	10.489	(0.369, 297.995)
Intercept term	4.227	2.323	3.311	0.069	68.516	

Note: "*" means $P < 0.20$.

regression analysis results, the possibility of healing would decreased by 0.562 times for every 1 mm increase in length of the interproximal contact. The decrease of this parameter could lead to the expansion of the food spillway, and consequently relieve these food impaction symptoms. Furthermore, the method of adjusting the length of the interproximal contact to treat food impaction was simple in clinical practice; because it could be reduced accordingly during the process of increasing the occlusal height without any special attention.

The remaining relevant parameter in this study was the occlusal buccal-lingual embrasure angle. Statistical analysis revealed that the difference in occlusal buccal-lingual embrasure angle before and after treatment was not statistically significant. However, clinical experience has proven that embrasure grinding was beneficial to the therapeutic effects. Actually, the buccal-lingual embrasure angle changed along with the occlusal height and length of the interproximal contactin clinical treatment. In most situations, the embrasure angle could only obtain a small change or even remain consistent after occlusal adjustment. Although the change in embrasure angle was not obvious, the area of the food spillway significantly increased after treatment, which would be effective to improve the food impaction.

Compared with a previous study, the occlusal adjustment used in this study was more moderate and the grinding degree was milder, which was more safe and effective for treating vertical food impaction. It should be noted that occlusal adjustment is irreversible, and could lead to permanent change in teeth morphology and occlusal relationship [18]. Therefore, doctors should pay attention to the following aspects during the course of treatment: grasp the indications rigidly and perform frequent but small amounts of adjustment, do not reduce the height of the functional tooth cusp to avoid the decrease in occlusal vertical dimension, and the occlusal force should tend to the axial direction after occlusal treatment [19].

Disclosure of conflict of interest

None.

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