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Changes in occlusal state of patients with mandibular prognathism after orthognathic surgery: a pilot study

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SUMMARY. **This study examined the occlusal state of patients with mandibular prognathism and compared it with that of adults with normal occlusion (controls). It also examined changes in occlusal state after orthognathic operations in these patients. The values of occlusal contact area and bite force in patients before operation were significantly lower than in controls, and occlusal pressure in patients was higher than in controls. The occlusal contact area and bite force of the patients 1 month after the operation had decreased to below preoperative values. These values 12 months after the operation had increased by 2.0 and 1.8 times in women and 1.4 and 1.4 times in men, respectively, compared with preoperative values. However, absolute values remained extremely low compared with those of controls. In contrast to the above, occlusal pressure reached its maximum value 1 month after the operation and at 12 months it was close to the value for controls. © 2001 The British Association of Oral and Maxillofacial Surgeons**

INTRODUCTION

Many patients who have had orthognathic surgery for dentofacial deformities have found improvement of occlusal form. Numerous studies have been reported on occlusal status before and after orthognathic surgery,[1–6] including occlusal contact area, bite force and occlusal pressure. However, there are few reports of measurements of the occlusal state in the dental arch. Recently, a pressure-sensitive sheet has been developed that is able to measure the occlusal state of the whole of the dental arch simultaneously, rather than individual teeth. It has already been used for analysis of occlusion in prosthodontics and periodontology and in paediatric dentistry. We have now studied the occlusal contact area, bite force and occlusal pressure of patients with mandibular prognathism of skeletal class III by using the pressure-sensitive sheet before and after orthognathic surgery. The findings were compared with those of a group of control subjects.

SUBJECTS AND METHODS

The subjects were 43 patients (21 men and 22 women, mean age 22 years, range 20–26 years) with mandibular prognathism and 32 adults (16 men and 16 women, mean age 21 years, range 20–24 years) with normal occlusion and dentition, as controls. The patients had setback orthognathic surgery of a mean of 4.9 mm (range 3.5–11 mm) on the right side and 5.0 mm (range 3.0–11 mm) on the left side, by sagittal split ramus osteotomy after preoperative orthodontic treatment. The difference in setback movement between the right and the left side ranged from 0 to 4 mm (mean 1.8). All the patients were diagnosed as skeletal class III without open bite or asymmetry. The distal and proximal fragments were fixed by a titanium miniplate and the duration of postoperative intermaxillary fixation was 7 days. Postoperative swelling continued for a few days and disappeared by 7–10 days after the operation. Clinical damage to the nerves and temporomandibular joints was not found after the operation.

To establish occlusal state, the occlusal contact area, bite force and occlusal pressure were measured by using the pressure-sensitive sheet (Dental Prescale® 30H-W type; Fuji Photo Film Co. Ltd, Japan) (Fig. 1) before operation and then 1, 3, 6 and 12 months after operation. All the subjects practised clenching in the intercuspal position before the measurement, and the pressure-sensitive sheet was inserted to fit the dental arch of the upper jaw. Teeth were clenched for 5 seconds with maximum bite force. The samples obtained were assessed by the analysing system, FPD-703® (Fuji Photo Film Co. Ltd) (Fig. 2). These values were compared with measurements obtained from the controls.

Measurements

The pressure-sensitive sheet for dentistry was developed in 1993. Although the material was initially used for industrial purposes, it was found that the U-shaped form

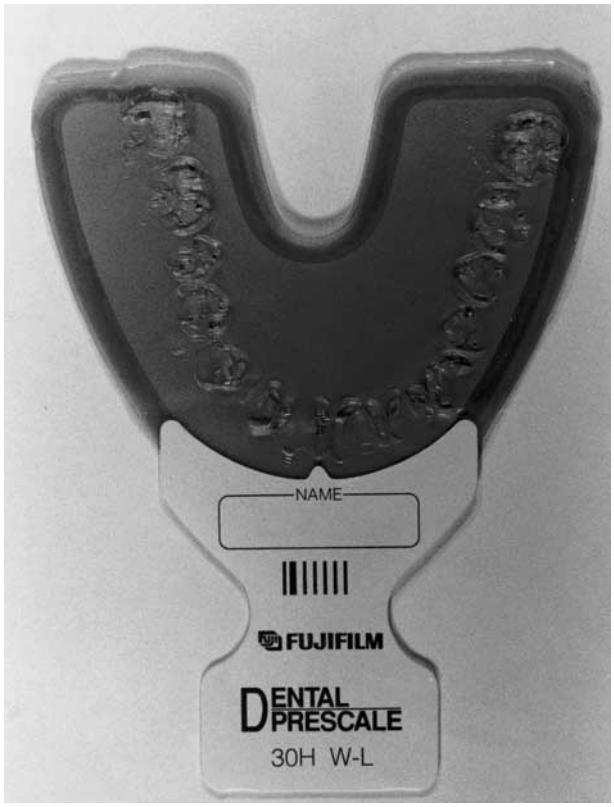

Fig. 1 Occlusal sensitive sheet (Dental Prescale® 30H-W type).

matched the shape of the dental arch. The material comprises two sheets of polyethylene terephthalate film (PET film) of about 90 μm thick with numerous microcapsules containing a red dye between them. When the pressure-sensitive sheet is pressed by clenching, the microcapsules in the PET film rupture according to the pressure, and various areas of the sheet are stained by the red dye at an intensity governed by the amount of pressure. The functional formula between the applied pressure and the density of red colour is constant. The computer analysing system calculates the density of the colour and therefore the occlusal state in the dental arch.

Statistical analysis

The results were expressed as mean (SD). The results from men and women were compared with the same-sex controls. Student's *t* test was used to test significance of differences. Correlation coefficients were calculated and significance was defined as probabilities of < 0.05.

RESULTS

Occlusal state before operation

The occlusal contact area and bite force of the patients before operation were significantly lower than those of the controls ($P < 0.001$). Although the absolute mean value of men was a little higher than that of women for both patients and controls, there were no significant differences in the same sex. Regarding occlusal contact area, the values for male and female patients were only 26% and 18%, respectively, of those of their control counterparts. The values for bite force in male and female patients were 28% and 19%, respectively, of those of sex-matched controls. In contrast, the occlusal pressure of the patients before operation was a little higher than that of the controls ($P < 0.05$). The absolute values for occlusal pressure in women, both patients and controls, were a little higher than those of the men (Table 1). However, there was no significant

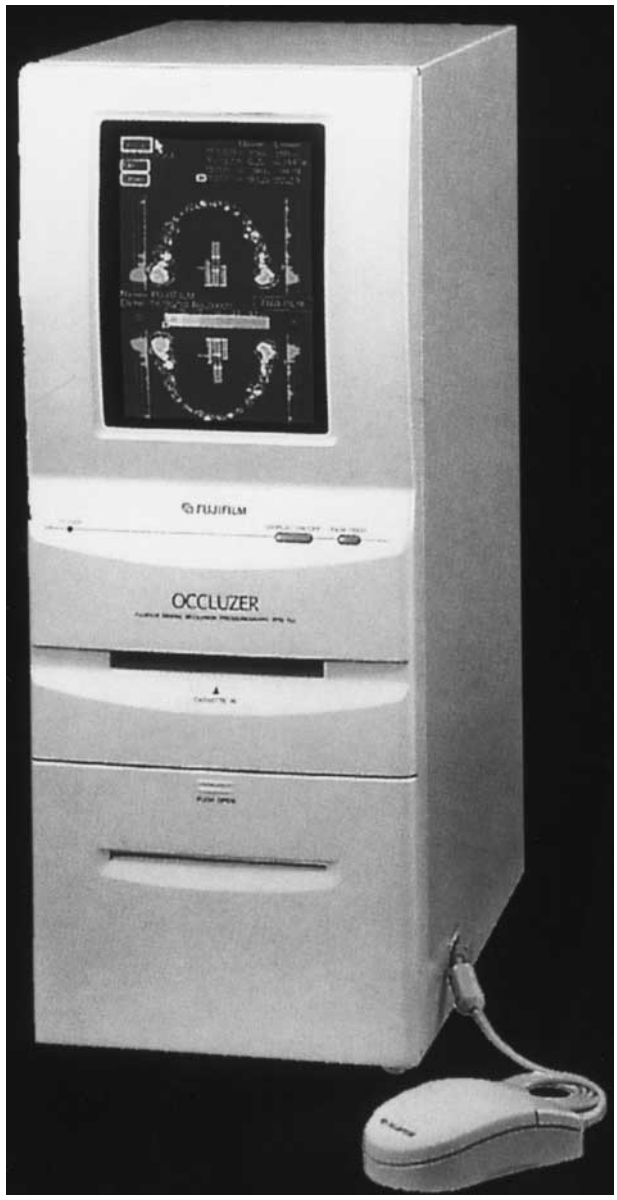

Fig. 2 Analysing system FPD-703®.

Table 1 Measurements of preoperative occlusal state; numbers are mean (SD)

Subject (sex)	Number of subjects	Occlusal contact area (mm^2)	Bite force (N)	Occlusal pressure (Mpa)
Control (male)	16	110.3 (24.5)	677.5 (163.1)	6.1 (0.4)
Control (female)	16	101.4 (32.6)	625.2 (200.4)	6.4 (0.5)
Preoperative (male)	21	28.4 (16.1)*	183.7 (99.9)*	6.9 (0.9)**
Preoperative (female)	22	18.1 (10.9)*	120.3 (64.0)*	7.0 (0.9)**

*$P<0.001$ compared with same-sex controls.
** $P<0.05$ compared with same-sex controls.

Table 2 Changes in occlusal contact area of patients with mandibular prognathism (mm^2); numbers are mean (SD)

Stage	Male ($n=21$)	Female ($n=22$)
Preoperatively	28.4 (16.1)*	18.1 (10.9)*
Postoperatively (months)		
1	6.4 (3.0)*	2.8 (0.9)*
3	20.9 (6.3)*	13.7 (8.3)*
6	30.6 (10.3)*	23.2 (10.3)*
12	40.0 (15.6)*	35.7 (9.4)*

*$P<0.001$ compared with the same-sex controls.

Table 3 Changes in bite force of patients with mandibular prognathism (N); numbers are mean (SD)

Stage	Male ($n=21$)	Female ($n=22$)
Preoperatively	183.7 (99.9)*	120.3 (64.0)*
Postoperatively (months)		
1	43.0 (15.4)*	22.2 (6.8)*
3	133.3 (34.9)*	92.5 (26.8)*
6	195.6 (62.5)*	151.3 (64.6)*
12	255.4 (98.7)*	220.2 (85.0)*

*$P<0.001$ compared with the same-sex controls.

difference in the values for occlusal state between men and women.

Changes in occlusal state after operation

The values for occlusal contact area and bite force had decreased slightly at 1 month after the operation. Six months after operation these values were greater than before the operation, and the increase continued gradually until 12 months after operation. Nevertheless, the occlusal contact area and bite force 12 months after operation were significantly lower than those of the controls in both sexes ($P<0.001$). The values for contact area and bite force as a percentage of control counterparts were 37 and 39 in men and 35 and 35 in women. Although men and women showed similar tendencies postoperatively, the values for men were higher than for women (Tables 2 and 3). On the other hand, the value for occlusal pressure increased significantly 1 month after operation, but decreased subsequently. Twelve months after operation, occlusal pressure of the patients was closer to that of the controls in both sexes (Table 4). Before operation and 1 month after the operation there was a significant difference ($P<0.05$) between controls and patients in both sexes.

Table 4 Changes in occlusal pressure of patients with mandibular prognathism (Mpa); numbers are mean (SD)

Stage	Male ($n=21$)	Female ($n=22$)
Preoperatively	6.9 (0.9)*	7.0 (0.9)*
Postoperatively (months)		
1	7.8 (0.8)*	8.1 (0.7)*
3	6.7 (0.8)	6.9 (0.6)
6	6.6 (0.7)	6.7 (0.8)
12	6.4 (0.7)	6.5 (0.5)

*$P<0.001$ compared with the same-sex controls.

DISCUSSION

Measurement methods

Generally there are two methods of occlusal examination: one focuses on the occlusal contact site or area of the teeth and the other focuses on bite force or its distribution in clenching. In the former, articulating paper,[7] wax[8] and a silicone rubber impression material[9,10] have been used, and in the latter biting force instruments have been widely used to make measurements from tooth to tooth.[11,12] Recently, electrical instruments such as the T-scan system[13,14] and photo occlusion wafer[15,16] have come into use, making measurement of the dental arch possible. However, these methods are complicated and are not applied widely in clinical practice. The pressure-sensitive sheet permits assessment of occlusal status of the dental arch easily and promptly. There are two types of sheet, which differ in their range of pressure: the 30H sheet is used for low pressure ranging from 3 to 13 MPa and the 50H sheet measures high pressure ranging from 5 to 120 MPa. In addition, there are three different kinds of wax, i.e. wax fixed to both sides of the film to clarify the occlusal contact site (W), to one side of the film (S)

and no wax (R). It is important to clarify the type of pressure-sensitive sheet being used. In this study, the 30H-W type was used, because the range of the 50H type is excessive for patients with mandibular prognathism. On the other hand, the values of pressure displayed when that value exceeded the limit of reliability might be incorrect with the 30H-W sheet. The reliability of the pressure is shown by the effective pressure. According to Kimura *et al*.,[17] $>95\%$ of effective pressure produces a reliable measurement.

Occlusal state before operation

When the occlusal state immediately before operation was compared, the absolute values and percentage rates of occlusal contact area and bite force in the patients were significantly lower than those of the controls ($P<0.001$). Moreover, the values of the women were lower than those of the men, although not to the point of significance. Although the measurement method was different from this study, similar results were reported by Throckmorton *et al*.[18] and Iwase *et al*.[14] We found that occlusal contact area always had a high correlation with bite force ($P<0.001$). The mean number of contact teeth in the upper and lower jaw that had marked the wax on the pressure-sensitive sheet was about 14 in the controls. On the other hand, the mean number of contact teeth of the patients was about half the number in the control group (6.7 in men and 5.8 in women) and in almost all patients there was contact between the premolar and molar tooth. The difference in bite force after preoperative orthodontic treatment in men and women seems to depend on the number of teeth in the occlusal area. In addition to these factors, the force of the masticatory muscles, the pressure applied to the periodontal ligaments and the moment arm are important factors. It seems that the variation of pressure from tooth to tooth in the patients was a result of occlusal interference or a decrease in the contact area as a result of preoperative orthodontic treatment.

Changes in occlusal state after operation

The occlusal contact area and bite force of these patients 1 month after operation was lower than before operation. Theoretically, the occlusal contact area and the bite force should have increased when an occlusal improvement was obtained by orthognathic surgery. There were several causes of this contradiction, such as the influence of pain caused by the operation, the inability to adapt to a new oral environment after the operation, anxiety about chewing strongly, the positional instability of the temporomandiblar joint and magnification of the periodontal ligament by the intermaxillary fixation. Kim and Oh[19] and Shiratsuchi *et al*.[20] reported that the maximum bite force in the molar was reduced when the intermaxillary fixation was removed at 1–7 weeks after operation. In our patients the bite force 6 months after operation exceeded the preoperative value and was even greater 12 months after operation. However, these values were still extremely low compared with those of the controls. These results confirmed those of other workers. Kim and Oh[19] reported that the bite force increased 2.4-fold in women and 1.7-fold in men 12 months after operation, and Iwase *et al*.[14] reported findings of 2.1-fold and 1.8-fold, respectively. Throckmorton *et al*.[18] reported that women had maximum bite forces ranging from 54% to 63% of controls and men from 70% to 82% of controls 500 days after operation. Maximum bite force in the women in the present study ranged from 32% to 37% of controls and men from 30% to 42% of controls 12 months after operation. It seemed that the bite force could improve further after 12 months. In addition, Throckmorton *et al*.[18] reported that mandibular setback increased the mechanical advantage of individual muscles, so the bite force increased because of a shortening of the moment arm, although damage to the muscles at the operation could have been responsible for the slow improvement of maximum bite force. Iwase *et al*.[14] suggested that the surgically induced changes in mechanical advantage were so small as not to influence the bite force. Ellis *et al*.[2] suggested several factors which had the potential to alter the bite force after the operation. These included changes in muscles, occlusal contacts, and the sensitivity of the teeth and temporomandibular joints.

The change of occlusal pressure after operation was not correlated with the occlusal contact area and the bite force, as it reached its maximum value 1 month after operation. It would seem that the occlusal pressure of a limited area, which gave pressure to only a small number of teeth, increased as a result. However, occlusal pressure gradually decreased from 6 months to 12 months and closely matched that of the controls. This tendency was the same in both sexes.

In conclusion, the occlusal contact area and bite force 12 months after operation were significantly lower than those of controls in both men and women. Occlusal state is influenced by the extent of neurological damage, proprioception in the periodontium, temporomandibular joint, vitality of teeth and amount of mandibular movement, so the correlation between occlusal state and these factors should be investigated. The bite force is said to increase as a result of training to chew strongly on chewing gum, and this occurred because the force of the masticatory muscles increased and the sensitivity of the periodontal ligament decreased. In view of this, training in jaw movement seems to be necessary to facilitate a successful, early functional occlusal state after orthognathic operations.

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