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Effect of orthodontically induced pain on velocities of mandibular movement

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Orthodontic pain can decrease the muscular activity in EMG studies. Changes in masseter muscle activity during orthodontic treatment are probably caused by discomfort, pain, or alterations in the occlusal relationship via tooth movement. The purpose of this study was to determine the extent of the effect of orthodontic pain on the velocities of mandibular movements. Thirty subjects were observed by using the K-6 model Myotonics kinesiograph for the measurement of jaw motion velocities before and after insertion of orthodontic posterior separators on the first, second, third, fifth days, and fifth day immediately after separator removal. Five consecutive opening-closing strokes were recorded and processed to evaluate the following parameters: 1) maximal opening and closing velocities, 2) average opening and closing velocities, and 3) maximal terminal velocity before tooth contact. Measurements of orthodontic pain were evaluated by using visual analogue scale **(VAS)** . The average velocity of 5 consecutive mandibular movement strokes on the 5 days were compared with the **VAS** score of pain by using the Pearson correlation statistic model. Neither the opening velocity nor the closing velocity was affected after separator insertion. In conclusion, mandibular movement velocities were not affected by orthodontic posterior separators.

Key words: mandibular velocity, orthodontic pain.

The fear of pain is one of the key factors that discourages patients from seeking orthodontic treatment. Orthodontic patients usually are informed that there may be some discomfort associated with the insertion of separators and initial arch wires. In addition, they are told that there will be discernible discomfort during periodic adjustment of the orthodontic appliances. Individual responses very widely and are believed to be a result of individualized pain perceptions. Factors of age, gender, and the magnitude of the orthodontic pain are not clear .

Ngan et al [2] reported that patients experienced significant levels of discomfort at 4 hours and 24 hours after insertion of separators and placement of arch wires. The cause of the pain resulting from orthodontic tooth movement is not entirely clear. Furstman and Bernik [3] suggested that periodontal pain was caused by a process of pressure, ischemia, inflammation, and edema. Burstone [4], in a study examining the pain caused by orthodmtic appliances, indicated that there was a wide range of individual responses when similar forces were applied to the teeth He stated that immediate and delayed pain responses existed in different patients. He speculated that the immediate response was related to the initial compression of the periodontal ligament immediately after placement of the arch wire. The delayed response, which began a few hours later was termed hyperalgesia of the periodontal ligament. Prostaglandins have been shown to cause hyperalgesia, which is increased sensitivity to noxious agents such as histamine, bradykinin, serotonin, acetylcholine, and substance P. Inflammation of gingival and periodontal tissues during orthodontic treatment may lower the pain tolerance by inducing tissue hyperalgesia. These tissues may then become responsive to stimuli that would not ordinarily evoke any reaction [4].

The pain resulting from orthodontic appliances decreased the muscular activity in EMG studies [5-7]. The number of bursts decreased substantially during the initial leveling period when the arch wires were adjusted and then recovered to near the original preactivation level [8]. Other studies showed that when EMG activity was taken into consideration a significant increase in the stretch reflex persisted in the painful muscle [8]. Whether the pain caused by orthodontic tooth movement affects the function of the mandible is not clear at this time. We can, however evaluate mandibular function by measuring the bite farce, chewing, mandibular movement velocities and so on.

The objective of this study was to evaluate the effect of inserting separators on mandibular movement velocities.

MATERIAL AND METHODS

Subjects

Thirty subjects had an average age of 26 years (range, 23 years old to 32 year, 1 month); none of the subjects in this study had any other orthodontic appliance treatment. Subjects consisted of 18 males and 12 females. Twenty-nine subjects were dentists or dental interns, and the other one was a physician. These 30 participants were in good physical health, free from any acute dental disease, and had taken no medication recently. All of them agreed to participate in this test after we carefully explained the experimental procedures, possible discomfort, and side effects caused by insertion of the separators in the mesial and distal contacts of the mandibular first molar. Consent forms were signed before we proceeded with the study.

Apparatus

A Myotronic K-6 system (Myotronics, Seattle, WA, USA) was used to recorded the mandibular movement velocities and the trajectory. Mandibular movement velocities were analyzed in the photo 2 scheme of the K-6 system The photo 2 scheme consists of a simultaneous vertical velocity record and the frontal view of lateral deviation during opening and closing movements. Opening-closing velocities were divided into 5 categories: (1) the maximal opening velocity from centric occlusion to maximal mouth opening (MOV, mm/s), (2) the average opening velocity from centric occlusion to

maximal mouth opening position (AOV, mm/s), (3) the maximal closing velocity from maximal mouth opening position to the centric occlusion (MCV, mm/s), (4) the average closing velocity from maximal mouth opening to the centric occlusion (ACV, mm/s), (5) the maximal velocity at 1 mm before tooth contact from maximal mouth opening . Photo 1 of the K-6 system depicts the trajectory of jaw movements in the sagittal and front planes during opening and closing of the mouth.

Orthodontic pain inducer

The orthodontic pain inducer consisted of orthodontic posterior separators. The separators were made out of Ormco (Ormco–640–0080), which is a blue color and radiopaque. They were placed at the mesial and distal contact points of the mandibular first molar. We did not lose any separators during the 5 days of the experiment.

Measurement of pain

A visual analogue scale (VAS) (Figure 1) was used to evaluate the orthodontic pain caused by the separators. The VAS form was modified by Lee[10] in 1998. Subjects were asked to mark the level of the pain before the separators were inserted. Then, they were asked to mark the level of the pain after separator insertion on the first, second, third, and fifth days, as well as immediately after the separators were removed on the fifth day.

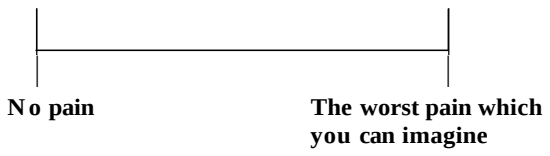

Figure 1. *Visual analogue scale (VAS) (10cm).*

Procedures

Subjects were seated comfortably in an upright position in a chair without a headrest. The labial surface of the mandibular incisors and gingivae were dried with sterilized gauze, and a magnet (Myotronics) was stuck onto the labial surface of the teeth with Urehesive (Bristol-Myers Squibb, St. Louis, MO, USA) according to the operating manual. Great care was taken to prevent the magnet from interfering with the closing movement of the mandibular dentition. The magnet was placed on the lingual surface of the mandibular incisors alternatively in the case of subjects with a deep overbite.

The photo 1 scheme of the K-6 system was first used to trace the trajectory of the open-close mandibular motion in the sagittal and frontal planes. Subjects were instructed to open and close the mandible as fast and as wide as possible. This was used as baseline data to check whether the test subjects would open wide enough at the same magnitude in subsequent experimental sessions. The photo 2 scheme of the K-6 system was subsequently used for recording the vertical velocity and the frontal view of lateral deviation simultaneouly during opening and closing movements.

Then 5 consecutive open-close movement motions were recorded. The subject was instructed to perform 5 continuous open-close jaw motions as fast as possible. All velocity records were stored on a disc for later analysis. Mandibular velocities were recorded on the first day before insertion of the separators, on the first day after insertion of the separators, on the second day, on the third day, on the fifth day, and on the fifth day immediately after removal of the separators.

Data analysis

All recorded data were stored and processed by Excel and Statica. The means and the standard deviations of the 5 consecutive open-close motion velocities were compared before and immediately after separator insertion by Wilcoxon's matched pairs test. Correlation matrices and Pearson correlation were used to evaluate the relationship between orthodontic pain and mandibular velocities.

RESULT

No separator was lost during the 5 day period among any of the 30 subjects. The coefficient of variation (CV) of mandibular movement velocity was about 10%; only the coefficient of variation of the maximal terminal velocity before tooth contact was 26.98% (Table 1). Most of the test subjects experienced the most severe pain during the second and third days (Table 2). But the amounts by which mandibular velocities were reduced differed (Table 2 and Figure 2). This means that pain did not affect mandibular velocities.

The association between orthodontic pain and mandibular movement velocity is not significant (Table 3). Correlation matrices and Pearson correlation were used to evaluate the relationship between orthodontic pain and the ratio of mandibular velocities, and there was no significance (Tables 4, 5). Then we used Wilcoxon's matched pairs test to find changes

Table 1. Coefficient of variation (CV) of mandibular velocities

Time	Average opening velocity	Maximal opening velocity	Average closing velocity	Maximal closing velocity	Maximal terminal velocity before tooth contact
Frist day (before separator insertion)	10.27%	11.41%	11.29%	11.83%	24.34%
First day (after sparator insertion)	9.95%	10.65%	8.94%	8.87%	23.88%
Second day	9.78%	10.82%	8.81%	9.46%	29.94%
Third day	9.00%	10.99%	8.49%	10.10%	27.46%
Fifth day	9.77%	11.82%	10.10%	10.42%	27.49%
Fifth day (after the separator removal)	8.90%	9.23%	8.64%	9.56%	28.79%
Average CV	9.61%	10.82%	9.38%	10.04%	26.98%

Table 2. Time of peak pain and the reduction in mandibular velocity (as compared to the first day before separator insertion)

Time	No of subjects recording peak pain	Average opening velocity	Maximal opening velocity	Average closing velocity	Maximal closing velocity
Frist day (before separator insertion)	**0**	0	0	0	0
First day (after sparator insertion)	4	12	14	12	12
Second day	12	14	12	12	11
Third day	10	14	13	11	11
Fifth day	2	11	10	13	9
Fifth day (after the separator removal)	1	11	10	10	10

* One person felt no pain during the entire experimental period.

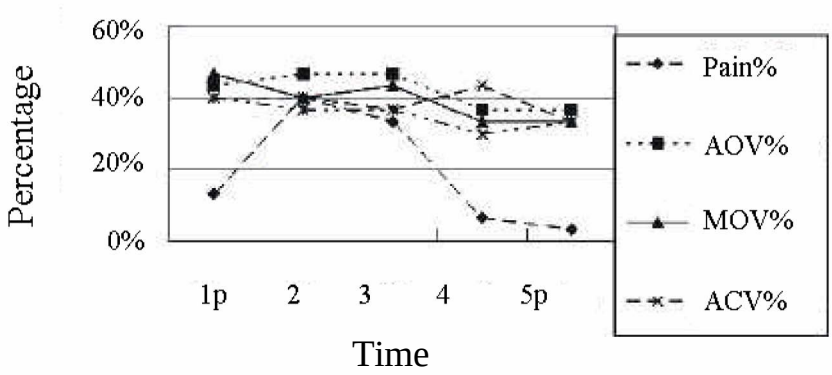

Figure 2. *Percentage of peak pain numbers and numbers by which the velocity was reduced*

Time: 1p : first day after the separator insertion.
2 : second day.
3 : third day.
5 : fifth day.
5p: fifth day after separators removed.
Pain % : percentage of the time of the peak pain numbers of subjects occurred at this point.
Mandibular velocity :
AOV %: percentage of times average opening velocity was reduced.
MOV %: percentage of times maximal opening velocity was reduced.
ACV %: percentage of times average closing velocity was reduced.
MCV %: percentage of times maximal closing velocity was reduced.

Table 3. Relationship between orthodontic pain and mandibular velocity (Correlation matrices) γ value

	VAS/AOV	VASIMOV	VAS/ACV	VASIMCV
1	-0.4779	-0.6961	-0.4567	0.0556
2	–	–	–	–
3	-0.8582	-0.802	-0.9181	-0.9088
4	0.5338	0.8375	0.2538	0.3645
5	0.513	-0.0324	-0.321	-0.167
6	0.234	0.3213	0.0482	0.171
7	-0.4425	-0.2569	-0.5439	-0.4201
8	0.3317	0.0422	-0.0793	-0.0732
9	0.3448	0.2002	0.5688	0.49
10	-0.149	-0.0618	-0.0571	0.0182
11	-0.708	-0.4968	0.1514	0.4945
12	-0.0761	-0.2222	-0.5299	-0.0635
13	0.086	0.0018	0.6167	0.414
14	-0.7293	-0.7343	-0.5514	-0.6033
15	0.1992	0.56	-0.3459	-0.1262
16	0.1785	0.0649	0.4008	0.0651
17	-0.1493	-0.1915	0.4419	0.1707
18	0.1293	0.7324	-0.6848	-0.5821
19	0.3177	0.3444	0.4028	0.3084
20	-0.4231	0.2466	-0.3159	-0.2264
21	-0.0667	0.1424	-0.0391	-0.0039
22	0.0324	-0.1441	0.266	0.2877
23	-0.0382	0.0646	-0.2694	0.0213
24	0.1383	-0.0051	-0.4184	-0.4354
25	-0.2449	-0.2757	-0.2796	-0.4466
26	0.8957	0.6447	0.6024	0.5852
27	-0.2189	0.3932	-0.4821	-0.5941
28	0.539	0.5659	0.546	0.4922
29	-0.0265	0.0467	-0.0525	-0.0294
30	0.1978	0.2975	0.5648	0.5037

* **One person felt no pain during the entire experimental period.**

Table 4. Relationship between orthodontic pain and mandibular velocities. (correlation matrices)

Correlation	VASlaverage opening velocity	VASlmaximal opening velocity	VASlaverage closing velocity	VASlmaximal closing velocity
γ : negative	14	12	17	14
y : positive	15	17	12	15

y : negative : as VAS increased, mandibular velocity decreased.
y : positive: as VAS increased, mandibular velocity increased.

Table 5. Relationship between orthodontic pain and the ratio of mandibular velocities (Pearson correlation)

VAS/ratio of mandibular velocity	γ	γ^2	P	N
VAS/average opening velocity	0.0832	0.0069	0.2666	180
VAS/maximal opening velocity	0.1164	0.0136	0.1197	180
VAS/average closing velocity	-0.0027	0.000007	0.9713	180
VAS/maximal closing velocity	-0.0080	0.000064	0.9153	180

y : the r value of the Pearson correlation
y^2 : the square of the r value
*** : $p < 0.05$ was considered significant**
N : total case numbers of 5 days.

in the maximal opening and closing velocities, the average opening and closing velocities, and the maximal velocity before tooth contact (Table 6).

DISCUSSION

We found an increase in of pain intensity from the first day after separators placement. The peak pain was recorded on the second day (40%) after the separators were inserted The second most frequent time for peak pain was the third day (33.33%). This is consistent with the finchngs of other studies. Some papers reported peak discomfort at 24 hours after treatment or separator placement[10-12]. One paper reported that peak pain occured between the second and third days after separator placement[13].

Orthodontic pain induced by separators decreased the activity of the masseter muscle in an EMG study , especially in the duration

Table 6. Changes in mandibular velocity by Wilcoxon's matched pairs test

Changes in mandibular velocities p-level	First day (after separator insertion)	Second day	Third day	Fifth day	Fifth day (after separator removal)
Average opening velocity	0.48	0.284828	0.452812	0.147049	0.075223
Maximal opening velocity	0.370942	0.259673	0.280223	0.097782	0.050711
Average closing velocity	0.465288	0.130601	0.289485	0.338863	0.057105
Maximal closing velocity	0.168315	0.099883	0.141399	0.019575"	0.04071"
Terminal maximal velocity before tooth contact	0.120455	0.274342	0.036793	0.27439	0.531179

*: A p-level < 0.05 was considered significant
Total case numbers were **30.** Changes in mandibular velocity were compared with the first day before separator insertion.

and number of low-amplitude bursts[5]. In this study, the correlations between orthodontic pain and mandibular velocities were low (-0.4 < r < 0.4) (Table **3).** This means that the pain caused by the separators chd not affect the velocities of mandibular movement. This *may* have been because the pain caused by separators was not strong enough to affect mandibular movement velocity.

The velocity of masticatory movement is developed by the mandible **as** it departs from the maxilla. The velocity of the chewing movement shows great variation and most greatly depends on the type of food, consistency of the chewed materials, and individual variations. To avoid the influence of food consistency on chewing movements, a model of an empty mouth movement was chosen for measuring the jaw motion velocities . In this study, subjects were asked to open and close the mandible **as** fast **as** possible, so we could observe a high empty open–close velocity[14].

According to Wilcoxon's matched pairs test analysis, there were no differences in the maximal opening velocity, the average opening velocity, the average closing velocity, and the maximal velocity before tooth contact between measurements on the first *day* and these taken after insertion of the separator. The maximal closing velocity on the fifth day and that after removal of the separators differed from the value on the first *day* before insertion of the separators. This might have been the result of separator placement for 5 days, which really caused tooth movement. This may have caused changes in the maximal closing velocity on the fifth *day*.

CONCLUSIONS

(1) The peak pain occurred between the second and the third days after insertion of the separators.

(2) Orthodontic pain caused by the separators did not affect the velocities of mandibular movement during the 5 day period.

(3) Changes in mandibular velocities were not significance by Wilcoxon's matched pairs test. But there was a difference in the maximal closing velocity on the fifth day and **that** measured

after removal of the separators. This may have been caused by movement of the teeth changing the occlusion

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矯正治療誘發之疼痛對下顎運動速度之影響

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因爲矯正治療中牙齒的移動，可能會引起牙齒的不適與疼痛而影響到正常的下顎功能，本研究是討論此矯正疼痛是否已經影響到正常的下顎功能。本研究在三十位成年受測者之單側第一大白齒的近心側及遠心側各置放一條齒間分離器（separator）來當做矯正疼痛的引發工具，然後用下顎運動圖 Mandibular Kinesiograph(MKG)來測量下顎三度空間未置放齒間分離器與放置後五天內下顎運動速度之變化。疼痛的評估以視覺類比尺度(VAS)來作記錄，K6 測量的項目包括了疼痛程度與平均張口速度、最大張口速度、平均閉口速度、最大閉口速度及最終閉口瞬間速度之關係。MKG 它是藉由紀錄傳感器之電磁向量的變化來描繪紀錄出下顎的三度空間之運動情形，因此方便性佳且所需的測量時間短，故本研究藉 MKG 來測量下顎運動速度的變化來得知其是否有因牙齒的疼痛而下降，以了解矯正治療所產生的疼痛是否影響口顎功能。結果發現大部份的受測者會因齒間分離器而產生不同程度的疼痛，且疼痛高峰期會出現在後牙齒間分離器置放後的第二天與第三天間；但在疼痛程度與下顎運動速度之變化方面，其相關性並不高，約有一半以上的受測者因放置後牙齒間分離器所產生之疼痛對下顎運動速度的影響並不大，僅呈現低度相關，故齒間分離器所產生之疼痛並不至於造成下顎之運動速度之改變。齒間分離器的放置，可能的確使牙齒產生移位，因而使牙齒的咬合狀態產生改變，所以使得下顎最大閉口速度發生變化，但就整體下顎運動速度來說其變化是極爲小的。

關鍵詞：矯正疼痛，下顎運動速度。

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