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The electromyographic activity of masseter and anterior temporalis during orofacial symptoms induced by experimental occlusal highspot

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SUMMARY **The aim of the present study was to investigate the short-term impact of an occlusal highspot on the occurrence of orofacial symptoms by collecting self-evaluation and using electromyography (EMG) evaluation. A rigid unilateral intercuspal occlusal highspot (A cast onlay of 0·5 mm) was placed on the right lower first molar of six adult volunteers (three males, three females), and remained for 6 days. Continuously all the induced orofacial symptoms were collected and the subjects scored the orofacial pain on a 10-cm visual analogue scale (VAS) during the placement of onlay. The surface EMG was recorded before the placement of onlay, during (on the 3rd and 6th day) and after the onlay was removed. Then the contractile symmetry of bilateral masseter (MAL, MAR) and anterior temporalis (TAL, TAR) was measured by using an asymmetry index. On the 3rd day of the placement of the occlusal highspot, all subjects complained of headache in right temporal region (mean-VAS ± s.d. = 3·7 ± 0·5); the activity of TAR at rest position of mandible increased significantly (P = 0·027). In addition, on the 3rd and 6th day with the highspot the EMG activity of the tested muscles during maximal voluntary contraction (MVC) was significantly reduced; the asymmetry index of bilateral anterior temporalis during MVC was increased significantly (P_{3rd} = 0·028; P_{6th} = 0·046). A unilateral occlusal highspot may make the ipsilateral anterior temporalis become tenser at rest position. Furthermore, the activity of bilateral anterior temporalis becomes more unsymmetrical during MVC although there are inter-individual differences between subjects. The changes in muscular activity may have some relationship with the occurrence of tension-type headache in temporal region.**

KEYWORDS: **experimental orofacial pain, electromyographic activity, occlusal interference, masticatory function, humans**

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Introduction

The stomatognathic function of masticatory system is usually adapted with the occlusal conditions (1). However, occlusal interference might induce local symptoms of tooth pulp or periodontia, even temporomandibular joint pain or intramuscular pain (2–8). The orofacial pain may be possibly attributed to the occlusal interference coming from the disharmony occlusal conditions, for example, experimental occlusal interference (2–5), malocclusion (6) or poor restorations (7). On the other hand, some epidemiological investigations failed to demonstrate any relationship between orofacial pain and occlusal interference (9, 10). Furthermore, some authors suggested that it might also contain other complex reasons, such as mental and psychical factors (11, 12). The real relationship has not been clear yet. As occlusal stability is relevant to muscular performance, several investigators have produced experimental interferences and

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investigated the impact of occlusal conditions on muscular activity by electromyography (EMG) (2, 3, 13, 14). Usually, the concomitant symptoms could be ignored or separately considered from EMG changes (3, 13). Otherwise, some researchers realized muscular activity might be associated with the development of some orofacial pain (2). Presumably, a reciprocal linkage between pain and abnormal muscle activity is a possible aetiological factor for the initiation and maintenance of many forms of chronic musculoskeletal pain disorders (15–17). Thus, the purpose of this study was to test the short-term effects on the jaw muscle activities induced by experimental highspot and if there is any relationship between the symptoms and the muscular activities.

Materials and methods

Participants

Six healthy subjects were recruited from among the freshmen enrolled in school of stomatology. Three women and three men, with a mean ± s.d. age of 22·5 (±1·0) years, having complete natural dentitions, Angle Class I occlusion, without symptoms and signs from the mandibular locomotor system based on interview and clinical examination, participated in the study. Each subject gave his/her consent to participate in the study following detailed information on the protocol and possible risks, received ¥500 for participation and was assured that he/she could leave the study at any time. The study protocol was reviewed and approved by the local ethics committee.

Experimental protocol

The occlusal interference was placed and remained on the place for 6 days. The real evoked symptoms were recorded on each day after the placement of the onlay. At the same time, the muscle pain rating was scored. Electromyography activity was recorded before, during the placement of the onlay (on the 3rd day and the 6th day), and after the onlay was removed. The EMG recordings were made in the afternoon. And the EMG examinations were performed by a single operator in the oral masticatory physiology laboratory of Peking University School of Stomatology. The operator was unaware of the aim of this study and the subjects' symptom.

Experimental occlusal interference

In each subject, a modified cast onlay made of nickel and chrome, with buccal surface, lingual surface and partial occlusal surface, was placed on the right mandibular first molar. The thickness of the onlay opposite the lowest point of the mesiopalatal cusps of the right maxillary molar was 0·5 mm (from the bottom of the occlusal fossa to the occlusal surface of the onlay). Impressions of the maxillary and mandibular dentitions were made with irreversible hydrocolloid and were poured into stone casts, followed by mounting of the maxillary and mandibular casts on a Hanau semi-adjustable articulator. In centric occlusion, the maxillary teeth and the mandibular teeth could contact only on the point with the height of 0·5 mm. The articulator imitated the lateral and protrusive movement. The buccal of the occlusal surface was wiped off to facilitate movement, which was the explanation for the partial occlusal surface of the onlay. Using glass lonomer luting cement* the onlay was bonded to the teeth and remained on the teeth for 6 days. Obviously, because of the influence of the depth of occlusal central fossa, the actual change in vertical dimension as measured in the interincisal region was slightly <0·5 mm after the onlays were cemented.

Symptoms collection

Before the placement of the onlay, on each day during the placement of the onlay and after eliminating the onlay, each subject expressed his/her symptoms freely. Continuously the subjects scored the maximal spontaneous pain of the day on a 10-cm visual analogue scale (VAS) with the lower extreme labelled 'no pain' and the upper extreme labelled 'most pain imaginable' (18). On each day, every subject scored the pain intensity three times just after breakfast, lunch and supper. The pain position was required to be marked in a coronal skeleton map or described in words. At the same time, the subjects were asked to describe the sensory, affective and evaluative quality of pain on a modified Chinese version of the McGill Pain Questionnaire (19). If the symptoms were persistent after eliminating the onlay, the symptoms would be collected in 2 weeks. The aforementioned information about symptoms would be recorded on a paper. It was convenient to

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collect the papers from every subjects on every evening before sack time as all of them lived in the school of stomatology.

Surface EMG recording

The subjects were instructed to sit on a level chair with a back rest keeping the spinal column straight, head vertically positioned with the horizontal Frankfurt plane parallel to the ground and asked to close their eyes. Surrounding noises were controlled. The operator was seated, moving as little as possible during the examination. The surface EMG was recorded when the mandible was in the resting position and the subject was asked to clench as hard as possible in the intercuspal position for 3–4 s (maximal voluntary contraction = MVC), through a neuropack EMG instrument (MEB-5508k) with bipolar silver electrodes (NE-132 B)[†]. Three times recordings were made both at rest position and when clenching maximally. The interval of the every two recordings was 10 min. In three times recordings, the minimum activity of rest position and the maximal activity of MVC were the final result of the recording day. Bilateral masseter (MAL, MAR) and temporalis (TAL, TAR) muscles were examined in each subject. The electrodes were positioned on the muscular bellies parallel to muscular fibres about 3 cm above and anterior to the mandibular angle in both masseters; and the electrodes were fixed vertically along the anterior margin of the muscle in temporalis (corresponding to the fronto-parietal suture) (20). Surface electrodes, coated with a conductive gel, were fixed onto the skin, which had been previously cleansed with ether. On the first recording day, the positions of the electrodes were preserved by sketch, which became the reference for the electrodes' positions on the other recording days. The measure program of the EMG instrument calculated the maximal voltage (MV) and the integral value (i.e. area, Ar) of EMG activity automatically.

To quantify the symmetry of bilateral muscular activity, the asymmetry index (AI) of bilateral MV was computed for each muscle and for each subject during resting and MVC (20):

$$AI_{MM} = (MM_R - MM_L)/(MM_R + MM_L)\%$$
$$AI_{TA} = (TA_R - TA_L)/(TA_R + TA_L)\%$$

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Statistical tests

Friedman's test of variance was used in the statistical analyses including average differences in the parameters (MV, Ar and AI) among the four stages (before the placement of the onlay, on the 3rd day and the 6th day during the placement, 7 days after the onlay were removed). If the result was significant, the non-parametric Student Newman–Keuls multiple comparisons test followed it. Significance was accepted at $P < 0{\cdot}05$.

Results

Orofacial symptoms evoked by the onlay

During the 6 days with the onlay, the subjects complained different degrees of orofacial pain. For every subject, the score of pain intensity on each day has a slight increase from morning to evening. For each day, the inter-individual difference in pain-intensity scores recorded just after supper was much smaller than those of the other two times. Therefore, the mean VAS value of each day was the mean of the scores recorded just after supper by the six subjects. A pain-time curve was drawn according to the development of the mean VAS value (Fig. 1). The curve that marked the value for each day showed that the mean of VAS value rose to the top (3·7 ± 0·5) on the 3rd day, and then dropped down. On the 1st day with the onlay (about 12 h after the insertion of the onlay), all subjects complained of fatigue of the muscles of right side face. On the 2nd day, the ache of right mandibular first

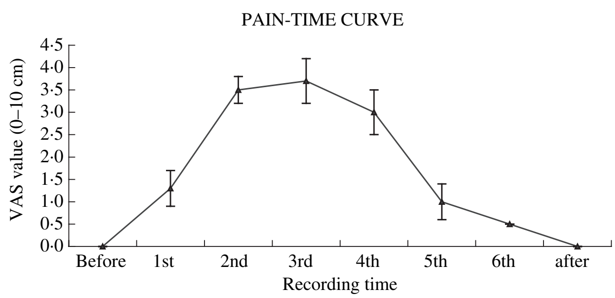

Fig. 1. The changes in the mean visual analogue scale (VAS) value (mean ± s.d.) during the 6 days with the onlay. Note that the VAS value rose to the top (3·7 ± 0·5) on the 3rd day. Before = before the placement of onlay; 1st–6th = each day during the placement of onlay; after = on the 7th day after the placement of onlay.

molar appeared in four subjects; and five subjects complained of right temporomandibular joint (TMJ) pain. On the 3rd day, two subjects felt the clicking of right TMJ; all subjects complained of headache of right temporal region; the pain of right TMJ still persisted in four subjects; the subjects described the headache as 'tight'(3/6), 'annoying'(5/6) and 'tender'(3/6); all subjects complained that they had to eat much slowly than before; but in their 'free words' expression, there was no complaint about sleep problem. On the 4th day, the complaint and the complaining subjects were the same as on the 3rd day; but the pain level was decreased; only three subjects still complained about the inconvenience of eating. On the 5th day, the clicking of right TMJ still persisted in two subjects; three subjects complained of headache of right temporal region; no one mentioned the eating problem. On the 6th day, the complaint and the complaining subjects were the same with the 5th day; but the mean of VAS value is only 0·5. All signs and symptoms of functional disorders disappeared within a week after eliminating the onlay.

Surface EMG

On the 3rd day with the onlay, the MV ($P = 0{\cdot}027$) and Ar ($P = 0{\cdot}028$) of TAR were significantly increased at rest position. The EMG activity of TAL at rest position also elevated, but it was not significant. There was also no significant change in MAL and MAR on the 3rd day (Table 1). And no modifications were found at rest position on the 6th day. But the MV and Ar of all four muscles were significantly reduced during MVC on the 3rd and 6th day compared with days before ($P < 0{\cdot}05$)(Tables 1 and 2).

The AI of MAL and MAR at rest position was significantly reduced ($P = 0{\cdot}046$) on the 3rd day, the AI of TAL and TAR at MVC, however, was significantly increased on the 3rd ($P = 0{\cdot}028$) and 6th ($P = 0{\cdot}046$) day (Table 3).

Discussion

In this study, a modified cast onlay with partial occlusal surface was used as an occlusal highspot. Comparing

Table 1. Comparison of MV of EMG activity of the four time stages during resting and MVC ($N = 6$)

	At rest position			MVC		
	MV (uv)	z	P	MV (uv)	z	P
MAL						
Before	10·5 (9·0, 12·3)			1887·5 (1484·5, 5744·3)		
3rd	13·0 (10·0, 18·0)	−1·051	n.s.	869·0 (401·5, 1400·5)	−2·201	0·028
6th	11·5 (9·5, 19·0)	−0·841	n.s.	1321·0 (837·5, 1761·5)	−1·992	0·046
After	12·5 (10·5, 19·8)	−1·214	n.s.	1814·0 (1283·0, 3288·3)	−1·153	n.s.
MAR						
Before	16·5 (11·3, 19·0)			1882·5 (1307·8, 3551·3)		
3rd	12·0 (9·8, 14·3)	−1·590	n.s.	704·0 (470·8, 1189·8)	−2·201	0·028
6th	10·0 (9·0, 15·3)	−1·363	n.s.	625·0 (481·8, 877·5)	−1·992	0·046
After	14·0 (9·0, 17·8)	−0·365	n.s.	1726·5 (1035·0, 3682·5)	−0·314	n.s.
TAL						
Before	35·5 (28·3, 47·3)			2500·5 (2368·3, 3948·5)		
3rd	54·0 (16·0, 106·3)	−0·943	n.s.	1966·5 (1193·3, 2721·5)	−2·201	0·028
6th	15·5 (13·5, 45·5)	−0·524	n.s.	1586·0 (340·8, 2229·8)	−2·201	0·028
After	15·0 (10·0, 46·30	−0·314	n.s.	2398·0 (1910·8, 3096·5)	−1·782	n.s.
TAR						
Before	31·0 (9·0, 63·8)			2626·0 (2403·5, 4303·3)		
3rd	59·5 (23·8, 107·5)	−2·207	0·027	1312·5 (590·8, 1915·8)	−2·201	0·028
6th	42·5 (17·8, 76·8)	−1·363	n.s.	1457·0 (782·5, 2285·8)	−2·207	0·027
After	21·5 (14·3, 38·0)	−0·946	n.s.	2026·5 (1492·0, 3443·0)	−1·363	n.s.

Before: before the placement of onlay; 3rd: the 3rd day after the placement of onlay; 6th: the 6th day after the placement of onlay; after: the 7th day after removing the onlay.
n.s., not significant; MV, maximal voltage; EMG, electromyography; MVC, maximal voluntary contraction.
The data are shown with mean and quartile (P_{25}, P_{75}).

Table 2. Comparison of integral data (Ar) of EMG activity of the four time stages during resting and MVC ($N = 6$)

	At rest position			Maximal clenching		
	Ar (mv*ms)	z	*P*	Ar (mv*ms)	z	*P*
MAL						
Before	13·5 (11·5, 15·0)			1592·5 (1960·5, 5282·0)		
3rd	13·0 (8·0, 18·0)	−0·105	n.s.	811·5 (356·8, 970·3)	−2·201	0·028
6th	14·0 (12·0, 20·5)	−1·625	n.s.	616·5 (183·5, 1259·3)	−2·201	0·028
After	16·0 (7·3, 19·8)	−0·734	n.s.	1678·0 (583·5, 3547·8)	−1·572	n.s.
MAR						
Before	20·0 (13·8, 24·3)			1360·0 (913·3, 3889·8)		
3rd	12·0 (8·8, 16·3)	−1·214	n.s.	701·0 (316·5, 1034·0)	−2·201	0·028
6th	13·5 (10·8, 20·0)	−1·214	n.s.	289·5 (118·3, 502·5)	−1·992	0·046
After	15·5 (10·3, 21·3)	−0·943	n.s.	1485·0 (359·8, 3732·5)	−0·734	n.s.
TAL						
Before	28·0 (20·5, 52·0)			2188·5 (1475·0, 3850·0)		
3rd	39·0 (12·3, 69·5)	−0·314	n.s.	1407·0 (1055·5, 2888·3)	−2·201	0·028
6th	19·0 (16·0, 40·3)	−0·524	n.s.	752·5 (134·0, 1842·5)	−2·201	0·028
After	24·0 (11·5, 61·3)	−0·315	n.s.	1750·0 (1000·5, 3457·3)	−0·734	n.s.
TAR						
Before	29·5 (9·8, 42·8)			2365·0 (1368·5, 3895·5)		
3rd	55·0 (41·5, 76·5)	−2·201	0·028	1034·0 (534·3, 1815·5)	−2·201	0·028
6th	33·0 (20·3, 65·5)	−1·153	n.s.	647·0 (296·5, 1375·3)	−2·201	0·028
After	20·0 (14·8, 44·0)	−1·753	n.s.	1805·0 (783·8, 3995·3)	−0·943	n.s.

Before: before the placement of onlay; 3rd: the 3rd day after the placement of onlay; 6th: the 6th day after the placement of onlay; after: the 7th day after removing the onlay.
n.s., not significant; MVC, maximal voluntary contraction; EMG, electromyography.
The data are shown with mean and quartile (P_{25}, P_{75}).

Table 3. Comparison of the AI of EMG activity of the four time stages during resting and MVC ($N = 6$)

	At rest position			MVC		
	AI	z	*P*	AI	z	*P*
MM						
Before	23·21 (13·21, 33·93)	q		10·86 (6·13, 35·24)		
3rd	7·17 (2·78, 16·51)	−1·992	0·046	24·96 (17·33, 40·41)	−0·734	n.s.
6th	9·55 (4·41, 18·27)	−1·572	n.s.	38·75 (26·12, 54·26)	−1·782	n.s.
After	10·00 (7·11, 13·37)	−1·483	n.s.	9·11 (3·10, 12·91)	−0·734	n.s.
TA						
Before	50·39 (28·17, 57·07)			2·76 (0·15, 8·08)		
3rd	25·94 (8·18, 49·42)	−1·153	n.s.	9·26 (6·26, 42·29)	−2·201	0·028
6th	21·27 (8·82, 48·66)	−1·363	n.s.	16·71 (5·34, 40·71)	−1·992	0·046
After	20·00 (13·40, 36·61)	−1·782	n.s.	12·84 (3·51, 16·11)	−1·782	n.s.

Before: before the placement of onlay; 3rd: the 3rd day after the placement of onlay; 6th: the 6th day after the placement of onlay; after: the 7th day after removing the onlay.
n.s., not significant; MVC, maximal voluntary contraction; AI, asymmetric index.
The data are shown with mean and quartile (P_{25}, P_{75}).

with the occlusal interference that had a full coverage on occlusal surface used in previous studies (3, 13), it was a strict intercuspal interference, without any confusion of laterotrusive interference. After cementation, the favourable retention ensured the same interference time among all subjects. The height of interference would not decrease in a long term. Besides, to exclude the intrinsic interference coming from malocclusion, only the subjects with Angle Class I occlusion were selected. As a result, with the 0·5 mm high unilateral intercuspal interference, the six normal adult volunteers complained different degrees of orofacial pain. The pain level rose to the top on the 3rd day, and then dropped down. The analysis of EMG activity of recorded muscles indicates that the unilateral occlusal highspot may make the ipsilateral anterior temporalis become more tense at rest position, as it also makes the activity of bilateral anterior temporalis become more unsymmetrical during MVC.

The orofacial pain evoked by occlusal interference

In the previous EMG studies on the effect of occlusal interference on the activity of masticatory muscle, some only reported an increase in activity of several jaw elevator muscles at rest (21) and some observed some orofacial symptoms (2, 3, 13), but a study also reported that the introduction of 0·25 mm height occlusal interference reduced masseter EMG habitual activity, and with the interference for 8 days none of the subjects developed any sign and symptom of temporomandibular disorder (TMD) (22). In the present investigation, a prominent occlusal highspot with the height of approximately 0·5 mm had been used. The elementary effect of this investigated unilateral occlusal highspot pertained to the symptoms of some orofacial pain, including the pain coming from the teeth, muscle and TMJ. Moreover, in the present study, both symptoms and the EMG activity were recorded in detail synchronously. Thus, it was possible to take a primary look into the pathophysiological link between experimental induced orofacial pain and the EMG activities of the masseter and temporalis muscles. The unilateral occlusal highspot remained for 6 days, and eliminated when the symptoms and signs lightened from development and aggravation. From pain-curve, the mean VAS value declined between the 3rd and 6th day despite still having the onlay on the molar, which gave a hint that the subjects adapt to the altered occlusal condition to some extent. But the individual's adaptation ability was not the same. It remained unknown what shape the pain-curve would change to if the remaining time of the onlay extended longer.

Until now, there seems to be minimal consensus on the relationship among the three topics, orofacial pain, TMD and occlusion (23). There was a confused attitude towards whether occlusion would be contributory to orofacial pain and what would be the mechanism if occlusion did take part in the pathologic events. But in this study, as a short-term effect, a unilateral occlusal highspot did induce pain and various symptoms in the orofacial and temporomandibular region. The presumable conclusion was, although occlusal interference of some degree could be well adapted as reported in a previous study (22), the adaptive ability had a limit. A higher occlusal interference exceeding the limit would induce some orofacial pain or some symptoms of TMD.

Relationship between EMG activities and regional pain

Resting EMG. On the third day with the onlay, the MV and Ar of TAR at rest position significantly increased, which might indicate that TA of the interference side contracted intensively. Instead of coming singly but in pairs, on the same day the VAS value from the subjects rose to the top. Furthermore, headache in the right temporal region was the major complaint. It suggested that the bigger tension of TAR had a certain relationship with the occurrence of the headache in the right temporal region. Up to the present day, the existence of a pathophysiological link between tonic muscle activity and muscle pain is still being debated. With a well-controlled study (24), Majewski and Gale suggested that no significant difference in EMG activity at rest of the temporal muscle between patients in pain and controls. However several studies of TMD and patients with orofacial pain have shown higher EMG activity at rest in the masticatory elevator muscles (17, 25). In this study, it still remains unknown, when a unilateral occlusal interference is introduced, which will take place first, bigger tension of TAR or headache in the right region. But a previous study (26) revealed that tonic jaw-muscle pain in humans caused by the infusion of hypertonic saline (5·8%) facilitated the short-latency jaw-stretch reflex, which could contribute to a reflex mediated muscle stiffness in conditions with muscle pain. In the present study, after the introduction of an occlusal interference, the resting EMG activity of TAR increased associating with the ipsilateral temporal region headache, which would also become a considerable evidence that a preferential action on brain stem pathways from the interneurons to the ipsilateral jaw-closing motoneurons (27). Moreover, in this study, the mean values of MV and Ar of TAL at rest position also indicated elevation of EMG activity on the 3rd day after the onlay placement, even though this was not significant. It was a hint that a higher EMG activity at rest showed bilaterally even when the muscle pain was unilateral. The increased EMG activity in TAL contralateral to the pain side suggested again that the higher muscular activity at rest depended on a central command.

The mechanism of chronic orofacial pain is still a focus of study (26–32). Almost all studies found that the postural EMG activity of jaw-closing muscles significantly strengthened reacting to the experimental pain. But the beginning time and lasting time of strengthened EMG were of great diversities, which made the researchers propose almost completely different conclusions. Whether the experimental pain does induce the increase of postural EMG activity of jaw-closing muscles (27–32), or whether the increase of postural EMG activity would be an element of a continuous positive feedback cycle that perpetuates chronic muscle pain (33), is the focus of controversy. Simply abnormal mandibular movement would increase pain perception in TMD patients (34). And lasting muscular pain would bring other influencing factors, such as stress and muscular fatigue, which might have feedback effects on the development of orofacial pain (35). Therefore, it is not clear in the present study if there is interactional effect between resting EMG activity and the muscular pain. Further studies are needed to clarify this aspect.

During the MVC. The result showed that the introduction of a unilateral intercuspal interference caused a linear distortion of clenching activity of bilateral masseter and anterior temporalis. On the 3rd day and the 6th day with the onlay, the MV and Ar of both sides of MM and TA significantly reduced during MVC. Convincingly, if stability is not provided by the dentition, i.e., there is a premature contact, jaw muscles must contribute to the stabilization and reduce the magnitude of the maximal contraction to avoid damage to the structure involved in the compensatory stability (36). Furthermore, the pain, which happened mainly on the interferenced side, would also cause a decreased capacity of the jaw-closing muscles to produce the maximum effort. The study of experimental jaw-muscle pain induced by hypertonic saline infusion has documented the same effect (31). But Christensen and Rassouli's study (3) of the influence of a rigid unilateral intercuspal interference on bilateral masseteric clenching activity showed that there was a significant motor facilitation on the side of the interference and a significant motor inhibition on the side opposite the interference. They compared the clenching activity with prematurity *in situ* and without prematurity *in situ*. The prematurity did not remain in the oral for some time. The result only showed the immediate effect of prematurity on the muscular activity, but did not contain the reactive effect of the symptoms and signs induced by the prematurity on the muscular activity. Therefore the immediate effect of occlusal interference was beyond the real condition of commonly encountered clinical occlusal interference.

Asymmetric index is an important parameter in the analysis of the symmetry of muscular activity (13). In the present study, the AIs of bilateral TA's MVC activity on the 3rd day and the 6th day with the onlay were significantly bigger than without the onlay. In fact, Maximum bilateral occlusal stability is a prerequisite for optimal neuromuscular generation of well-adjusted bilateral clenching forces: optimal occlusal stability appears to facilitate bilateral central motor commands of equal strength (37). In normal adults bilateral muscles of the head, neck and upper trunk act harmoniously to keep the mandibular positions and take part in the mandibular movements (38). In Alajbeg's study (39), the AIs of TA during MVC and 50% MVC were compared between patients of TMD and normal controls. They found that the AIs of patients were much bigger. The bigger asymmetry of bilateral TA indicated the harmony of both sides of TA lost and might do some harm to the function of mastication system. Nevertheless, in the present study, on the 3rd day with the onlay the AIs of bilateral MM's activity at rest position were significantly reduced, which contained the compensatory effect of MM. The compensatory effect of MM might be larger than TA, which might be the reason for the smaller AI. But when the remaining time of the onlay was longer (i.e. on the 6th day), the compensatory effect of MM was not evident any more.

Limitations of the study

Sample size and long-term investigation. The relatively small sample size is a limitation of this study. Moreover, with the guarantee for no irreversible damage to the participants, investigation of a longer-term effect of occlusal interference will get more convictive result.

The limitation of surface EMG recording. Some methods were used to control the influence of interferential factors, for example, preserving the same positions of electrodes in different recordings, excluding the influence from malocclusion, little difference in the subjects' age, etc. But the gender or inter-individual differences in EMG activity did not control well.

The limitation in the standardization of pain intensity continuous scoring. In the process of this study, some methods were used to standardize the continuous scoring of VAS between day recordings. First, the subjects were recruited from the medical students, and all gave consent to report their discomfort faithfully. Moreover, on each day every subject scored the pain intensity three times. The pain-intensity scores recorded just after supper was found to have smallest inter-individual difference, and then were used to count the mean VAS value among all the subjects. But the individual orientation in the continuous scoring couldn't be completely avoided.

Conclusion

As a short-term effect, a unilateral occlusal highspot did induce pain and various symptoms in the orofacial and temporomandibular region. A unilateral occlusal highspot may make the ipsilateral anterior temporalis become tenser at rest position, and the activity of bilateral anterior temporalis becomes more unsymmetrical during clenching. The changes of muscular activity may have some relationship with the occurrence of tension-type headache in temporal region.

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