J Headache Pain (2001) 2:89–96

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Functional and clinical evaluation of dysgnathic patients before and after surgical-orthognathic treatment

Received: 17 April 2000
Accepted in revised form: 22 May 2001

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Abstract In this study, we evaluated, as far as clinical and functional aspects are concerned, the eventual and precocious improvement obtained with a combined orthognathic and surgical treatment on a group of 27 dysgnathic patients. In particular, pain (muscle contraction, headache, cervical and TMJ pain), otovestibular symptoms (hypoacusia, acouphonia, vertigo), interocclusal distance, stableness at rest, deglutition and mandibular movements were evaluated. We compared the different indexes taken in consideration before and after treatment, with a precocious follow-up (four months after the end of the post-surgical orthodontic treatment of adjustment). First results obtained look positive even if they need a further evaluation in the future.

Key words Facial pain • Orthognathic surgery • Otovestibular symptoms

Introduction

"Craniomandibular disorders" is a complex term describing a syndrome that concerns the stomatognathic apparatus, with or without involving other structures and organs such as the otovestibular or oculomotor apparatus, rachis, pelvis and plantaris support [1–3]. It is quite difficult, in such a complex situation, to summarize etiopathogenesis, so this syndrome is usually considered a dysfunction of the stomatognathic apparatus able to interfere with many other systems (e.g. otovestibular, rachidian, muscular and postural systems) [4, 5]. Among its many and complex functions such as chewing, phonation, breathing, miming, deglutition, what mostly involves the whole system (together with breathing), is deglutition [6, 7].

Each person swallows 1600–2000 times in a 24-hour period (therefore while asleep and awake), usually by putting, when possible, the teeth in the maximum intercuspal position. Therefore, the right occlusion is a decisive factor in stabilizing the jaw for what concerns the neuromuscular position [8, 9].

When the stomatognathic apparatus is in rest position, there is a space of 1.5–2.0 mm (freeway space) between the dental arches and therefore the movements of the skull are not limited by occlusal interferences. In this situation, the muscular tone has the function to keep this position [10]. Any anatomic variation of the vertical dimension, or the presence of a malocclusion, can change the original neuromuscular rest position so that compensatory mechanisms begin to change the whole balance.

Each time we swallow, the central nervous system receives information from periodontal, articular and muscular periferal receptors. This information, after being completed and elaborated together with other information coming from different corporeal districts, is used to control both the spatial position of the skull and to condition the neuromuscular apparatus to keep the jaw rest position or to sensitize it to perform other functions (such as speaking or chewing) [11].

Maintenance of the postural balance is usually free from one's will, and takes place mostly at a cerebellar level by extrapyramidal pathways which elaborate the visual, vestibular and proprioceptive information coming from the whole organism. When keeping a correct balance becomes difficult, a conscious effort must be made to regain it [12].

There is then the possibility that psychological interferences create changes in this balance (parafunctions) with worse effects (too much uncoordinated work) on the neuromuscular system [13, 14].

The etiologic factors of headache and craniofacial pain, and their reciprocal influences, are not well understood [15]. Local factors deriving from craniofacial or cervical structures include: local neurologic diseases, craniofacial muscular functional diseases, and postural or maxillary structure alterations. Psychological factors can favor dysfunction or parafunction of craniofacial muscles able to alter maxillary structure over time. According to the classification of headache and craniofacial pain of the International Headache Society (IHS) [16], craniomandibular disorders are considered in two different groups: "oromandibular dysfunction" and "temporomandibular (TMJ) alteration".

Oromandibular dysfunction is included in the group of tension-type headaches, since has a possible pathogenic factor, and is defined as "a condition which presents three or more of the following symptoms: TMJ popping during mandibular movements, limited or irregular movements, pain during extreme movements, block in opening mouth, pressing teeth and other parafunctions (biting or pressing tongue, lips or cheeks)".

TMJ alteration is grouped with "headache or facial pain associated with cranial, neck, eyes, ears, nose and paranasal sinuses, teeth, mouth or other facial or cranial structures", and is defined as "light or moderate pain growing from TMJ together with articularis capsula pain, maxillary pain during functional movements, decreased wideness of movements, crepitation noise during articular movements". The clear limitation of the IHS classification is the tendency to put together symptoms of muscular dysfunction together with symptoms of articular dysfunction. Therefore, the American Academy of Orofacial Pain suggested in 1990 [17] an integration to the IHS Classification: next to the entry "TMJ", it added "masticatory muscles", so to distinguish problems arising from intracapsular TMJ lesions and problems arising from muscular dysfunction.

The relation between head and neck postural alterations and headache and facial pain is still debated [15], mostly because of the lack of precision in the classification of painful syndromes. While there is no agreement in the literature on the relation between intracapsular TMJ lesions and cervical postural troubles [18–23], it is frequent, in clinical practice, to observe myogenic cephalalgia, tension-type headache, cervical pain and postural alterations [15]. However, the presence of many variables makes it difficult to establish a cause and effect relation. When subjected to stress and muscular parafunctions, some patients with a functional situation already compromised by postural alterations can increase the activity of long muscles of the neck, therefore increasing the possibility of cervical pain, together with myogen facial pain and, eventually tension-type headache [23]. Even the relationship between parafunctions, craniofacial muscle fatigue and tension-type headache is still debated. Double-blind studies showed that affected patients have increased pain at pericranial muscle palpation compared to non-cephalalgic patients [23–27], and this pain increases during headache attacks [25].

In the present study, we evaluated the clinical and functional changes in a group of dysgnathic patients after orthognathic and surgical treatment.

Patients and methods

The study was based on a population of 27 dysgnathic patients, 10 men and 17 women, aged 8–34 years.

All patients underwent an occlusopostural investigation [28] following diagnostic and instrumental protocols. The *diagnostic protocol* included dental, otorhinolaryngologic, physiatric, phoniatric and postural examinations (ophthalmic, orthopedic and medical examinations were performed only if necessary). *Instrumental examinations* included craniomandibular-cervicodorsal electromyography [29], jaw kinesiography, baropodometry, stabilometry, cephalometry on standard skull radiographs, analysis of dental casts, photographic documentation of the face in frontal and lateral views, and TMJ sonography [30, 31].

The information obtained was used to plan a treatment for each patient, which aimed at correcting both facial dysmorphia and malocclusion. In those cases which presented acute symptoms of craniomandibular disorders, we began with a muscular deconditioning treatment with orthopedic devices (orthotic bite or repositioning bite) in order to re-establish the neuromuscular balance and therefore to cool symptoms before further interventions. Treatment of the malocclusion consisted of an orthodontic preparation, followed by surgical correction and, after that, a final orthodontic phase of adjustment which lasted on the average for 6 months. Each surgical correction, with the exception of palatal expansion, required an individual intrasurgical repositioning bite manufactured on casts mounted on an articulator and surgical set-up based on occlusopostural data derived from the previous examinations.

After 4 months, we measured the effects of treatment on some signs and symptoms: pain at TMJ palpation both externally and through the internal auditory meatus, pain at the external pterygoid, masseter and temporal muscles, mandibular hypomobility, articular noise in opening and closing the mouth, cervical pain, hypoacusia, acouphonia, vertigo and headache.

All patients were invited, both at the beginning and at the end of the treatment, to quantify the level of pain of these symptoms, spontaneously or during examination, on a visual analogic scale (VAS) [32]. To record these data, the scale was divided into three segments, each of which represented one level of pain: light, moderate, severe.

All patients were suffering from tension-type headache (TTH), according to the IHS classification [16, 33, 34]. The diagnostic criteria to distinguish TTH from other types of headache, in particular migraine, were clinical and based on the quality, intensity, location and duration of pain, beyond the absence of autonomic symptoms.

A total of 17 patients (63%) had cephalalgia (Table 1). The mean age was 26 years for the 4 patients (14%) who referred light symptoms, 24 years for the 9 patients (34%) with moderate pain, and 27 years for the remaining 4 patients (14%) with severe pain. Duration of the primary headache was more than 2 years in 65% of cases, 1–2 years in 25% of cases, and less than 1 year in 10%. All cephalalgic patients presented a muscular contraction of pericranial and masticatory muscles, beyond an incremented level of muscular activity measured by electromyography.

The statistical analysis used to evaluate the results was the chi square test carried out on the percent changes in the intensity of symptoms or signs.

Patients with monolateral or bilateral crossbite (Table 2) pre-

Table 1 Pain symptoms in the 27 patients

Symptom	Intensity	Pre-treatment, n (%)	Post-treatment, n (%)
Headache	Absent	10 (37)	18 (67)
	Light	4 (15)	6 (22)
	Moderate	9 (33)	3 (11)
	Severe	4 (15)	0 (0)
Cervical pain	Absent	8 (30)	18 (67)
	Light	8 (30)	5 (19)
	Moderate	10 (37)	4 (15)
	Severe	1 (4)	0 (0)
TMJ pain	Absent	12 (44)	18 (67)
	Light	8 (30)	8 (29)
	Moderate	6 (22)	1 (4)
	Severe	1 (4)	0 (0)

TMJ, temporomandibular joint

Table 2 Dentoskeletal defect and surgical treatment of the 27 patients with malocclusion

Patient	Gender	Age, year	Malocclusion type	Surgery
1	F	24	Right crossbite	Mandibular osteotomy with rotation
2	F	24	Bilateral crossbite	Surgical palatal expansion
3	M	10	Bilateral crossbite	Surgical palatal expansion
4	F	25	Class III	Maxillary advancement and mandibular withdrawal
5	F	27	Class III	Surgical palatal expansion
6	F	31	Class III	Maxillary advancement and mandibular withdrawal
7	F	22	Class III	Surgical palatal expansion
8	F	32	Class III	Maxillary advancement
9	F	18	Frontal and right crossbite	Mandibular withdrawal and rotation
10	F	19	Class III	Maxillary advancement
11	F	19	Class III	Mandibular withdrawal
12	M	17	Right lateral and anterior open bite	Left lateral sectorial osteotomy
13	F	17	Ogival palate with bilateral crossbite	Surgical palatal expansion
14	M	30	Class III	Mandibular withdrawal
15	M	24	Class III	Maxillary advancement and mandibular withdrawal
16	F	14	Bilateral crossbite	Surgical palatal expansion
17	F	17	Anterior open bite	Maxillary frontal sectorial osteotomy
18	M	19	Ogival palate with bilateral crossbite	Surgical palatal expansion
19	F	25	Ogival palate with bilateral crossbite	Surgical palatal expansion
20	M	9	Ogival palate	Surgical palatal expansion
21	M	31	Class III with crossbite	Surgical palatal expansion
22	F	26	Right crossbite	Mandibular osteotomy with rotation
23	M	30	Class III	Maxillary advancement and mandibular withdrawal
24	F	15	Bilateral crossbite	Surgical palatal expansion
25	M	19	Ogival palate with bilateral crossbite	Surgical palatal expansion
26	F	24	Class III	Maxillary advancement
27	M	20	Ogival palate with bilateral crossbite	Surgical palatal expansion

sented a discrepancy between the diameter of the mandible (distance between the middle point of the vestibular grooves of the right and left first molars) and that of maxilla (distance between the mesiovestibular cusps of the right and left first molars) >4 mm.

The 17 patients aged 18–26 years, i.e. at the end of the growth period, underwent an orthodontic treatment lasting on the average 18 months, and then a surgical correction of the defect with palatal expansion. Two patients with anterior or right crossbites (Table 2) underwent surgical mandibular rotation, in one case with withdrawal, because the crossbite was associated with jaw asymmetry. The 3 patients aged 10, 14 and 15 years (i.e. in growth) had a bilateral crossbite. The 9-year-old patient had an ogival palate with bilateral crossbite. These 4 children presented, in addition to the malocclusion, a "third medium syndrome" with functional respiratory problems due to constriction of the superior nasal airways and nasal septum deviation. Their respiratory functions [35, 36] were investigated using total body plethysmography (Gould body box with Fleish Pneumotachometer) and spirometry. Their orthodontic treatment before surgery consisted in the application of Burstone appliance just before surgery, taking the expansion place during the surgical procedure. The midpalatine suture expansion associated with nasal septum surgical dysjunction creates a distension of the choanae which tends to solve respiratory problems [35, 36]. After surgery, these patients underwent an orthodontic treatment of adjustment.

Twelve patients with a third class malocclusion (Table 2) who presented, on cephalometric analysis according to Cervera, a discrepancy of 3.5 mm at least on laterolateral teleradiography between the maxilla and the mandible underwent an orthodontic treatment of 1–3 years followed by a combined surgical procedure consisting in mandibular withdrawal and maxillary advancement according to Obwegeser and Dal Pont and Le Fort I technique.

In cases with maxillary hypoplasia corrected with Le Fort I surgical approach, the orthodontic preparation took at least 18 months.

The 7 patients who received surgical mandibular withdrawal according to Obwegeser and Dal Pont, one of which was with rotation, and the 3 patients who received mandibular osteotomy with rotation underwent a presurgical orthodontic treatment on the average of 18 months.

The two patients with open bite (anterior and lateral) underwent surgical sectorial osteotomy after an orthodontic preparation of 6 months. The orthodontic phase of adjustment after surgery lasted for all the patients on the average 6 months.

Results

The post-treatment evaluation showed an improvement in headache (Table 1), although this was not significant ($p>0.05$). TMJ pain and pain at palpation of cervical muscles statistically improved after therapy ($p<0.05$).

In terms of otovestibular symptoms (Table 3), most patients seem to benefit from treatment ($p<0.05$).

TMJ and external pterygoid pain (Table 4) reduced in a statistically significant number of cases ($p<0.05$). For intra-auricolar pain, our study recorded a statistically significant reduction in pain for the left ear ($p<0.05$) but not for the right ear ($p>0.05$).

Table 5 presents changes in mandibular rest position: analysis of results after treatment shows its turning to physiological range in a statistically significant ($p<0.05$) number of cases. Likewise, the pattern of deglutition (Table 6) and the mandibular traces of movements (Table 7) also improved after treatment.

Table 3 Otovestibular symptoms

Symptom	Patients, n (%)	
	Pretreatment	Post-treatment
Acouphonia		
Present	9 (33)	2 (97)
Absent	18 (67)	25 (93)
Hypoacusia		
Present	12 (44)	4 (15)
Absent	15 (56)	23 (85)
Vertigo		
Present	5 (19)	1 (4)
Absent	22 (81)	26 (96)

Table 4 Pain sensation, before and after treatment

Symptom	Patients, n (%)			
	Pretreatment, right	Pretreatment, left	Post-treatment, right	Post-treatment, left
TMJ pain				
Present	12 (44)	10 (37)	2 (7)	2 (7)
Absent	15 (56)	17 (63)	25 (93)	25 (93)
External pterygoid pain				
Present	13 (48)	17 (63)	13 (48)	17 (63)
Absent	14 (52)	10 (37)	14 (52)	10 (37)
Intra-auricular pain				
Present	5 (19)	8 (30)	1 (4)	1 (4)
Absent	22 (81)	19 (70)	26 (96)	26 (96)

Table 5 Mandibular rest position and interocclusal distance, before and after treatment. Values are number (percent) of patients

	Pre / Post treatment									
	Δ≤0.2 mm		0.2<Δ≤0.5 mm		0.5<Δ≤1 mm		1<Δ≤2 mm		>2 mm	
Rest position	0 (0%)	1 (5%)	2 (9%)	18 (62%)	2 (9%)	4 (15%)	21 (73%)	2 (9%)	2 (91%)	2 (9%)
Interocclusal distance	6 (19%)	0 (0%)	13 (48%)	1 (5%)	1 (5%)	5 (19%)	1 (5%)	12 (71%)	6 (23%)	1 (5%)

Table 6 Deglutition, before and after treatment. Values are number (percent) of patients

	Pretreatment phase		Post-treatment phase	
	Present	Absent	Present	Absent
Coincidence with habitual occlusion	22 (81%)	5 (19%)	25 (93%)	2 (7%)
Coincidence of habitual occlusion and deglutition pathways	19 (70%)	8 (30%)	25 (93%)	2 (7%)

Table 7 Mandibular characteristics on kinesiography, before and after treatment. Values are number (percent) of 27 patients

	Pretreatment	Post-treatment
Frontal view		
Coincidence		
Present	15 (56)	17 (63)
Absent	12 (44)	10 (37)
Deviation, right		
Δ≤2 mm	12 (43)	8 (28)
2<Δ≤4 mm	14 (52)	17 (62)
4<Δ≤6 mm	1 (5)	1 (5)
Δ>6 mm	0 (0)	1 (5)
Deviation, left		
Δ≤2 mm	12 (43)	9 (33)
2<Δ≤4 mm	1 (5)	1 (5)
4<Δ≤6 mm	1 (5)	1 (5)
Δ>6 mm	0 (0)	1 (5)
Crossbite		
Next to maximum opening	2 (9)	2 (9)
Next to maximum closing	5 (19)	7 (24)
Absent	20 (71)	18 (67)
Sagittal view		
Coincidence		
Present	6 (24)	12 (43)
Absent	21 (76)	15 (57)
Crossbite		
Present	21 (76)	15 (57)
Absent	6 (24)	12 (43)

Discussion

Many patients seen at our orthodontic and maxillofacial surgery ambulatories present dysfunction of the stomatognathic apparatus; among them, only 30% complains of pain, while another 30% reveals instrumental and occlusal dysfunction but does not feel any pain. Surely we found most of the dysfunctional subjects among patients with orthodontic problems, even if we also found dysfunctional problems in patients without malocclusion.

The aim of our study was to determine if the symptoms could be improved or resolved by re-establishing correct occlusion with orthodontic and surgical treatment. All the patients of our study underwent a re-evaluation of signs and symptoms 4 months after the end of the orthodontic treatment of adjustment following surgery. Statistically significant changes in cervical and TMJ pain were referred by the patients during habitual movements respectively of the neck and of the jaw both monolaterally and bilaterally [39, 40]. Masticatory muscles, mostly the external pterygoid, showed, in some cases, pain at palpation [27] more evident in patients with craniomandibular dysfunction, even if absence of pain did not mean that the system was working well [41–43]. Pain at retrocondylar intra-auricular palpation is mostly due to internal derangement and possible rotation of the condyle [44–46]. The otovestibular system, often involved in our patients as far as hypoacusia, acouphonia and vertigo are concerned, seems to get statistically better after treatment. Headache is one of the most frequent symptoms referred by our patients.

The apparent improvement of headache is not statistically significant and, in our opinion, in some cases, the esthetic and functional improvement largely contributes to face the problem with a better psychological attitude. The use of a computerized kinesiographic program permitted a graphic comparison of the data, both useful in the diagnostic and in the post-surgical phases as far as mandibular rest position, movements and pattern of deglutition are concerned: their improvement can be correlated to a restoration of the muscular and gnatological functions. As previously stated one of the main functions of the stomatognathic system is to control the mandible rest position, so that the different movements of the head will not interfere with the stability of the system itself. The range of this position varies physiologically from 0.2 mm to 2 mm. The habitual interocclusal distance statistically is considered normal from 1.5 and 2 mm, and can be decreased because of a muscular contracture following malocclusion (as happened in our patients) or more often because of a psychophysical distress of the patient.

The vertical dimension of occlusion (DVO) can be increased because of an early contact obliging the central nervous system to contract the buccal muscle to open the mouth so to release the upper and lower arches from the forced occlusion [47–49].

During swallowing dental arches should face according to the intercuspal position in dental occlusion [50], however this cannot always happen either for neuromuscular problems in performing this act, or for the presence of occlusal alterations such as missing teeth, which oblige the tongue to keep a wrong position to reach a good seal and so to destabilize swallowing itself [51, 52].

Sometimes a releasing plane should be necessary so that the tongue can work as a bite, changing the swallowing pattern. Even the presence of early deflecting contact during the effort of the tongue to swallow can create a sliding movement of the jaw and then a TMJ destabilization [53].

The functional or the maximum opening and closing movements of the mouth are extremely important to evaluate the health of the stomatognathic apparatus.

By kinesiographic tracing, we can graphically reconstruct those movements, in frontal and sagittal views and even compare them. A discrepancy in frontal view can be the expression of a TMJ internal derangement or muscular spasms. A deflection in maximum opening can reveal a muscular lack of balance, while a cross usually goes with an articular alteration [54, 55].

The comparison of sagittal traces reveals articulation or proprioceptive problems. Then the patients, after being orthodontically treated in accordance with the presurgical plan, undergo surgical correction of malocclusion. Statistical analysis underlines an improvement of the jaw rest position and the opening/closing paths after treatment. For what concerns swallowing, while the treatment corrected the occlusal disharmony, the tongue position and incoordination could be solved by the use of orthopedic device in the presurgical phase or by a logopedic rehabilitation.

The continuous process of post-treatment stabilization resulting from the progressive neuromuscular readaptation further improves, and this seems already clear for patients with longer follow-up.

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