Gait & Posture 67 (2019) 25–30

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Full length article

Impact of orthognathic surgery on the body posture

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ARTICLE INFO

Keywords:
Orthognathic surgery
Standing position
Occlusion dental
Jaw abnormalities
Proprioception

ABSTRACT

Background: Postural control is classically described as being based on the visual, vestibular, and proprioceptive musculo-articular sensory systems. The influence of mandibular proprioception on postural stabilization remains controversial. Most previous studies analyzed how postural stability is influenced by partial changes in mandibular proprioception (dental occlusion and jaw position).

Research Question: In the present experiment, we asked whether drastic mandibular changes, resulting from orthognathic surgery (including dental, joint and muscular efferents), modify postural control.

Methods: The analyzes were performed in 22 patients tested before, and 2.5 months, after orthognathic surgery for treatment of dysmorphic jaws. Experiments were performed under 4 experimental conditions: 2 visual conditions: Eyes Open (EO) and Eyes Closed (EC), and 2 occlusal conditions: Occlusion (OC: mandible positioned by the contact of the teeth), and Rest Position (RP: mandible positioned by the muscles without tooth contact). The analyses focused on head orientation in the frontal plane and on postural stabilization in a static task, consisting of standing upright.

Results: The results show that, 2.5 months after orthognathic surgery, head orientation in the frontal plane was improved, since patient's external intercanthal lines became closer to the true horizontal line when they were tested EC and in OC condition. Postural responses, based on the wavelet transformation data, highlight an improvement in maintaining an upright stance for all the tested sensory conditions. However, such improvement was greater in the EC and RP conditions.

Significance: These results show, for the first time, that after drastic mandibular changes, the weight of proprioceptive cues linked to the mandibular system may be so enhanced that it may constitute a new reference frame to orient the head in space, in darkness, and improve static postural stabilization, even in the presence of visual cues.

1. Introduction

Postural control is usually described as being based on information from the vestibular, visual, and proprioceptive systems [1–3]. In the past few decades, the specific role of the cranio-mandibular system has been highlighted by numerous studies, most of them involving dental proprioception. Nevertheless, mandibular position is controlled by three types of proprioception: masticatory muscle proprioception, mainly by the masseter muscle; joint proprioception, from the temporomandibular joint; and dental proprioception, by the periodontal ligament [4]. These three types of proprioception are mediated by the trigeminal nerve. The neuroanatomical substrates have been described in the rat, which originate from trigeminal nucleus, projecting to all levels of the spinal cord [5,6], and from different cerebellar areas, which send fibers to the vestibular nuclei [7]. Such data strongly support the hypothesis of functional implications in postural function.

The literature evaluating the impact of the mandible on postural control reports contradictory conclusions. Some studies have suggested that postural stability is influenced by dental occlusion, jaw position [8,9], and temporo-mandibular disorders (TMD) [10]. These are supported by studies showing that mandibular position can influence head position via the sterno-cleido-mastoidian muscle [11], and that TMD

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https://doi.org/10.1016/j.gaitpost.2018.09.019
Received 11 June 2018; Received in revised form 11 September 2018; Accepted 19 September 2018
0966-6362/

impairs the upper cervical range of motion [12]. Moreover, manipulated occlusion position is associated with deviations of the spine position, in humans [13], as well as in animals [14]. On the contrary, other studies have reported a lack of correlation between dental occlusion or temporo-mandibular disorders on posture [15–18] and gait control [19]. We postulate that such contradictions in the literature may be due to the fact that studies dealing with the impact of mandibular changes on postural control cover only part of the proprioceptive mandibular system.

Studies reporting a relationship between occlusion and postural control have suggested that the influence of dental occlusion on posture depends on the difficulty of the postural task and on the sensory cues available to stabilize body in space. Specifically, dental occlusion comes into effect in dynamic postural conditions [20–22] and its importance grows as the other sensory cues become scarce, i.e., in the absence of visual cues or when the use of proprioceptive leg information is disturbed [20].

The present experiment investigated whether drastic mandibular changes resulting from orthognathic surgery (including dental, joint and muscular afferents), modified postural control. Orthognathic surgery is a surgical act of the head aimed at refocusing the maxillary and/or mandibular bones bases in the three planes of space, and at balancing mandibular proprioception. In general, the specific role of the cranio-mandibular system in postural control has focused on the deleterious effects caused by malocclusions or TMD. To answer this question, we analyzed the impact of improved mandibular position on posture during a simple static task consisting of standing upright. We hypothesized that drastic mandibular changes have major effects, resulting in an improvement of postural control.

This approach also allowed the analysis of the adaptive reweighting of sensory cues in postural stabilization after orthognathic surgery. Based on the previous studies cited above, the present hypothesis was that orthognathic surgery leads to more important postural changes in the absence, than in the presence, of visual cues, and that dental proprioception represents a minor participation in comparison with the rest of the proprioceptive mandibular changes.

The aim of the current study was to determine whether drastic mandibular changes, resulting from orthognathic surgery, modified postural control. The primary outcome was to compare the effect of orthognathic surgery on postural stabilization in a static task, consisting of standing upright. As a secondary aim, the analyses focused on head orientation.

2. Materials and methods

2.1. Participants

The study sample was obtained from patients at the Department of Maxillofacial Surgery who required orthognathic surgery. A full explanation of the study aims and procedures was provided to each patient and written, informed consent was obtained. The study was approved by local ethics committee (CPP Sud Méditerranée I). The sample size was determined on the standard deviation for the mean spectral power density measure, as calculated from a previous study [20] with a significance level of $\alpha = 0.05$ and 90% power level. Twenty-two patients were included: 6 men (aged 23.8 ± 5.0 years (mean ± SD); height: 179.5 ± 8.0 cm; body weight: 69.3 ± 11.3 kg) and 16 women (aged 26.2 ± 4.2 years; height 167.8 ± 7.2 cm; body weight: 63.8 ± 8.3 kg). Orthognathic surgery was needed to treat dysmorphic jaws in sagittal dysmorphy (class II (n = 10), class III (n = 10) Fig. 1) or vertical dysmorphy (n = 2). Participants were included if they did not have vertigo, tinnitus, acute cephalic pain, TMD, occlusal instability, physical, neurological or sensory disorders, musculoskeletal impairment in the past two years, or medication that might influence balance.

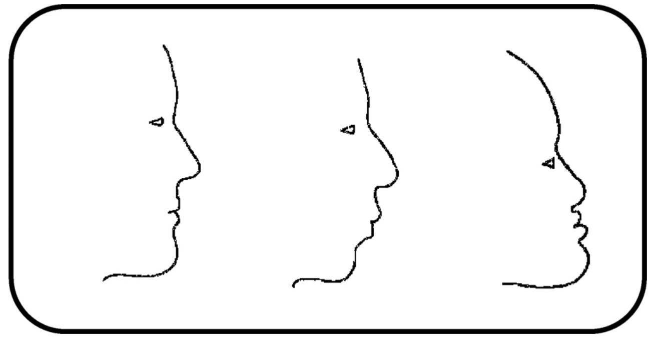

Fig. 1. Skeletal classification of sagittal abnormalities (*Middle* retrognathia: class II; *Right* prognathia: Class III) compared to normality (*Left* Class I).

2.2. Experimental protocol

To determine the effect of orthognathic surgery on postural control, analyses focused on upright stance stabilization and head orientation. Postural recordings were performed with the participants standing quietly, without making voluntary gestures, and with their hands held in a natural position along the vertical body axis. To analyze the particular weight of the dental sensory system within different mandibular sensory information, the postural performance of participants was examined under 4 experimental conditions: 2 occlusal conditions: Occlusion (OC), i.e., when the maximum number of teeth were in contact with the closed mouth, and Rest Position (RP) i.e., when there was no dental contact while the mouth was slightly open after swallowing (participants were required to maintain this position and no cotton rolls were employed to avoid involving dental proprioception); and 2 visual conditions: Eyes Open (EO) and Eyes Closed (EC). In the EO condition, participants fixated on a visual target placed 3 m in front of them, at eye level, to prevent exploratory saccades. In the EC condition, they were asked to imagine the position of the memorized visual target. The different experimental conditions (EC-OC, EC-RP, EO-OC, EO-RP) were repeated three times and presented in a randomized order. Between two trials, a rest period of 2 min was observed to avoid muscle fatigue. Patients were tested two times: before surgery and 2.5 months after, to allow for functional muscular recovery after surgical trauma [23].

2.3. Data acquisition and processing

Static posturography was performed with participants standing in a standardized position (bare-foot, feet 30° apart) on a stable force-plate (Médicapteurs, Nice, France) sensing the vertical force exerted by the feet on the ground during upright stance. The displacement of the center of foot pressure (CoP) in the anteroposterior and mediolateral directions was sampled at 40 Hz for 25.6 s. Data processing were carried using PosturoPro and Win Posture software. Postural performance was quantified using the body sway area (the area of the confidence ellipse including 95% of the CoP displacements, mm^2), the velocity of the CoP (mm/s) and the spectral power density of the recorded signal in three frequency bandwidths (0.05-0.5 Hz, 0.5–1.5 Hz, and 1.5–10 Hz, arbitrary units: AU, which corresponded to the slowest, medium, and highest movements, respectively) in the sagittal and in the frontal planes. A wavelet analysis was performed yielding a three-dimensional time-resolved and frequency-resolved chart of the instant power of the recording. These steps for analyzing body sway are illustrated in Fig. 2. The procedure for processing sway parameters has been described previously [20,24]. Finally, the possible changes of the average position of the participant was analyzed using the x and y coordinates of the CoP.

Head orientation was measured with the participants standing upright and barefoot on a landmark, with their back near a white wall, to