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Integrating posture into orthodontic–surgical treatment

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ABSTRACT

The correction of large inter-maxillary or craniofacial elastics often suggests orthognathic surgery, as a complement to orthodontic preparation. This depends on cephalic extremity, which generates important bone movement, affecting the centre of gravity of the head and muscular and articular activities. Many receptors act on main body balance and lead to distant lesions, when affected, just like better coordination of the jaws can help to reduce associated postural imbalance. Literature is poor in this field. We are therefore presenting some concepts of general posture and means to assess the initial postural context of our patients to optimize the integration and orientation of our ortho-surgical treatment. Overall care of patients and interdisciplinarity are factors of success and treatment stability.

KEYWORDS

Posture, orthognatic surgery, spine, orthopaedics, physiotherapy, function

INTRODUCTION

The entire organism is organized into body segments that can move relative to each other (head, upper limbs, lower limbs, trunk etc.) and that have their own center of gravity. In the orthostatic position (subject in the balanced, upright standing position), the positioning of the different centers of gravity must project toward the floor of the entire body's center of gravity to stay within the support shape corresponding to the plantar surface[6] (fig. 1). Any displacement of one of the segmental centers of gravity shifts it in relation to the body's line of gravity (which passes through the vertex in front of the cervical spine, intersects L3, follows the femoral axis, and passes in front of the knee and tibiotarsal joint).

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This increases the distance between this segment's center of gravity and the body's line of gravity, thereby creating an imbalance that must be compensated by movement and by stabilizing the other body segments. Postural adjustments are then made by the muscles (mostly the pararachidians and lower limb extensors), tendons, capsules, joint ligaments, and the overlying tissue. A prolonged postural perturbation will lead to inadequate balance control and unstable movement.

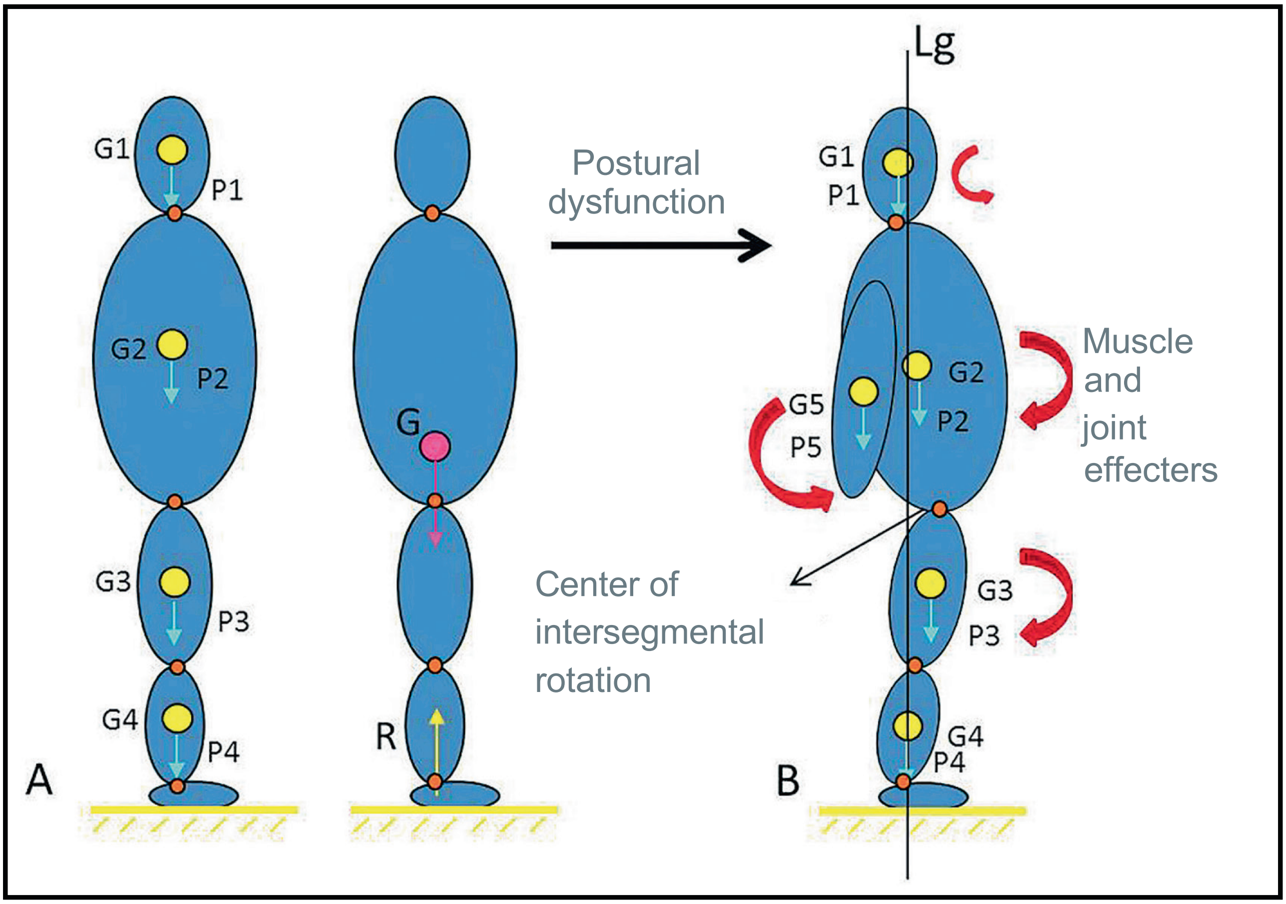

Figure 1
A. Position of the centers of gravity of the different body segments on the line of gravity. B. Postural adaptation to imbalance. Decentralization of the centers of gravity, mobilization of the segments in relation to each other to maintain balance using the muscles (According to Bouisset[6]).

During periods of growth, this can be explained as a possible morphological or functional adjustment; however, outside the period of growth, an imbalance that persists can regularly be attributed to injury (pain, tissue destruction, osteoarthritis, etc.).

Maxillary displacement by orthognathic surgery can create or correct such an imbalance. Cephalic equilibrium is complex and must be harmonized with the other skeletal parts which include the cervical spine, skull, mandible, hyoid bone, aerodigestive tract, extensor muscles joining the neck muscles (notably the sub- and suprahyoid muscles), tongue, masticators, platysma muscles, nape muscles, and paravertebral muscles. This harmony also extends to aponeuroses and particularly to the dura mater[10,26]. It is therefore logical to assume that correcting strong class II skeletal, class III, or pronounced facial asymmetry would impact the posture of the head and consequently that of the rachis and hence the entire body (fig. 2).

The literature is lacking in this field. There are already a few conclusions regarding the morphological relationships between the facial typology and the cephalic posture. Only the model created by Solow Tallgren[31] repeated several times[33,30,15,9] for reliability proposes that the forward inclination of the cervical spine that is reduced by cervical lordosis is associated with severe maxillomandibular discrepancies and a decrease in facial prognathism.

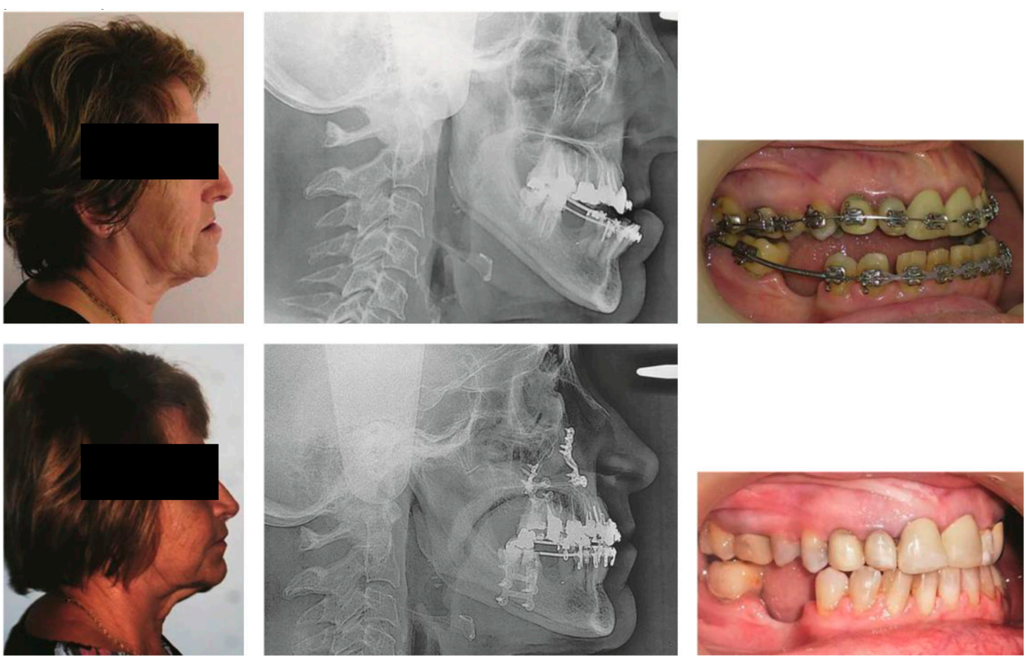

Figure 2

Clinical case. Orthodontic–surgical correction of a hyperdivergent skeletal class III malocclusion. Significant changes in the center of gravity of the head and bearing of the head. Reduction in the cervical curvature and posterior straightening of the spine. Influence on cervical proprioception and temporomandibular joint? (Increase in contact)? Influence on the position of the postural sensory system (inner ear, eyes)?

Nobili[22], Garcia[15], and D'Attilio[9] have observed a more retruded position of the cervical spine in subjects with class III malocclusions with reduced lordosis and a more forward position. Subjects with class II malocclusions had more pronounced lordosis or an extension of the head in relation to the spine and were more frequently afflicted with pathologies of the cervical vertebrae such as occipitalization of the atlas or vertebral fusions[2].

Studies published on the impact of orthodontic–surgical treatments are even rarer and are limited to the cephalic extremity. Overall, they conclude that in class III surgeries, the lack of postural shift is because of the displacement of the jawbones or because of a significant short- or medium-term increase (1–4 years) in the extension of the head relative to the high cervical spine and to cervical hyperflexion[1,18,20]. During class II surgeries, D'Attilio9 and Philipps[24] observed the opposite immediately after mandibular advancement surgery; they observed significant head flexion.

Owing to stabilometric evaluation, the simulation of mandibular advancement by orthosis[4] has shown a disruption in the general static (increased oscillations of the center of gravity) and more posterior repositioning of the center of gravity. Based on spinal X-rays, two studies[25,17] have investigated the postural influence of class II orthognathic surgeries, (mainly by mandibular advancement) and of class III surgeries (by maxillary advancement), and they have shown a decrease in the inclination of the sacral plateau and therefore retroversion of the pelvis, which can be explained by the forward displacement of the facial center of gravity, followed by advancement of one of the two maxillas. Lumbar and cervical lordoses are significantly reduced in class II corrections because of the cervical curvature and tensions created between the sub- and suprahyoid muscles subsequent to mandibular advancement. Head flexion and relaxation of the nuchal extensors are stimulated as they control the significance of cervical lordosis and the extent of its forward inclination. These adaptations are involved in keeping visual and labyrinthine postural sensors in their original position[33].

GENERAL POSTURE

General posture is a complex, active body function. It is autonomous and self-regulated and positions the different body segments in space at any given moment. The postural system comprises different sensory inputs that inform the nerve centers, which in turn choose an appropriate motor response for maintaining equilibrium. This balance can be either static or dynamic. Posture plays a pivotal role because the postural system is continuously working. In static equilibrium, the functions of the postural system provide resistance to the forces of gravity, thereby keeping humans erect and balanced despite external constraints. In a state of dynamic equilibrium, the postural system anticipates and plans movement accounting for exterior and interior factors. All these mechanisms do not cost much in terms of the amount of muscular energy exerted, and more importantly, they do not cause any pain.

At the beginning of the 19th century, the first person to actually consider a possible postural "sense" that would maintain one's posture against the wind was Sir Charles Bell. Since then, many researchers from different specialties have studied the impact of their specialty on overall posture and have even gone as far as creating an actual discipline or at least a specific way of dealing with the issue. These specialists included Romberg (neurologist), Flourens (ENT specialist), Sherington Longet (for proprioception), and Bricot[7] or Gagey[12,13,14] (posturology or stabilometry).

The development of the postural system throughout human evolution has permitted the acquisition of bipedalism, which is unique to humans. During childhood, the first postural frameworks are genetically programmed. Then, as humans develop owing to the combination of environmental factors, the creation of motor functions is facilitated. All postural motor synergies are stored in memory to create a repertoire. Owing to neuroplasticity, humans continue learning and adapting throughout life.

Input sensors of this system

These sensors can either be external, which provide information about the body's position in relation to external elements (eye, inner ear, foot, and skin), or internal sensors, which provide intrinsic information such as the position of corporal segments in relation to each other (rachidian proprioception, manducatory apparatus) (fig. 3).

The eye permits visual input that informs the central nervous system of verticality, position, and body movements in space. Central retinal and foveal vision record the fixed image, and its peripheral vision captures the notion of movement. The eye therefore functions as an external sensory receptor, but it also useful in proprioception using the oculomotor muscles to provide information on the position of the eye in the orbit. The six oculomotor muscles also facilitate binocular vision and consequently depth and distance perception. Seventy-five percent of oculomotor activity takes place automatically as determined by the postural system, but twenty-five percent of this activity is voluntary. The range of eye movements is limited and must be linked to wider displacement of the head obtained via the cervical muscles. A convergence disorder or paralysis can lead to compensatory inclination or rotation of the head, accompanied by a particularly scapular shift in the belts, and facial or occlusal asymmetry (fig. 4).

The inner ear (or labyrinth) ensures vestibular input. Using the three semicircular canals, the vestibule provides information concerning angular acceleration in the three dimensions of space. Using the saccule and utricle, the otolithic system provides information concerning linear acceleration. It is therefore a pure external sensor of

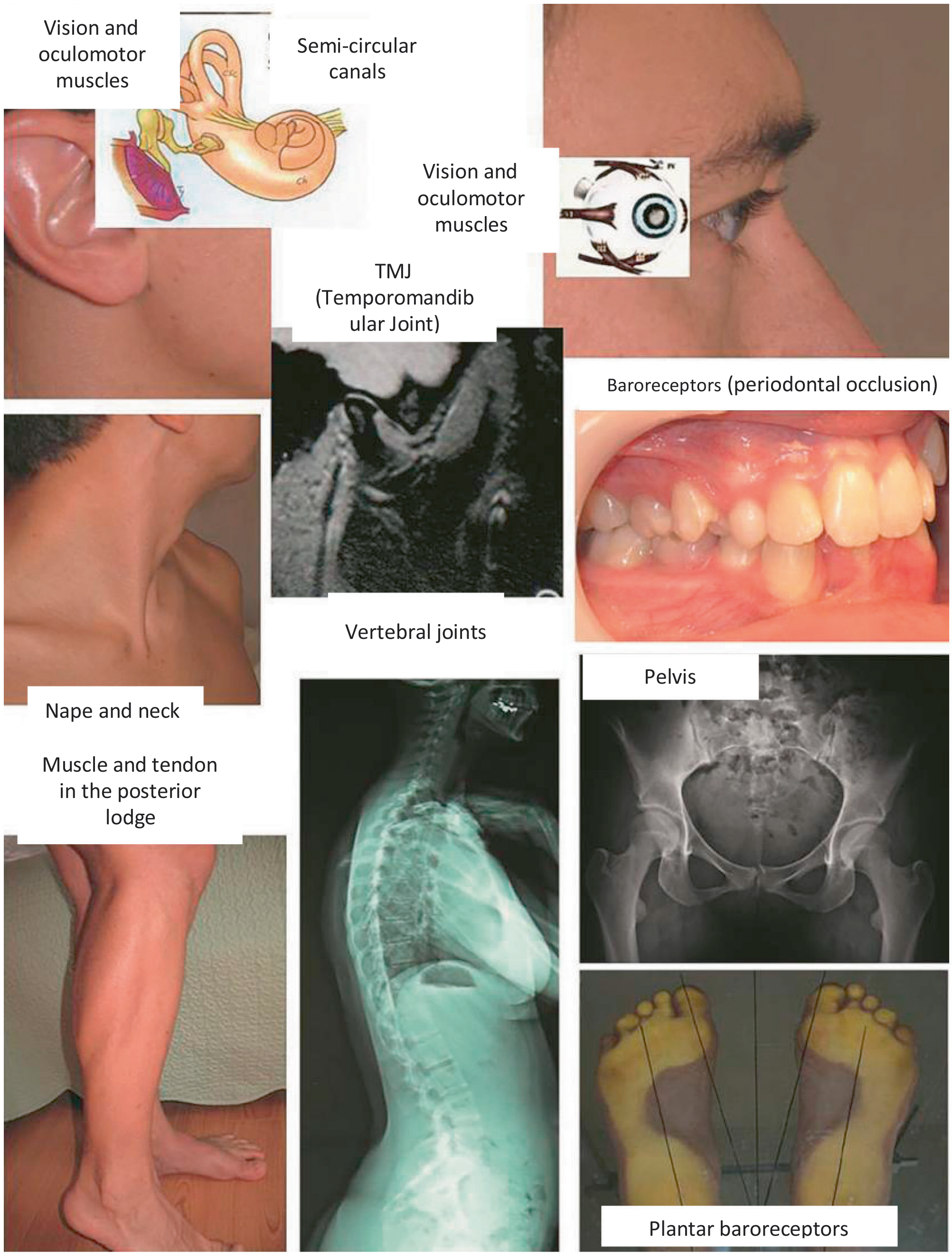

Figure 3
Postural sensors.

movement and head position. Its role is therefore to regulate the position of the head, body, and eyes to stabilize the image captured by the retina. Any discrepancy or distortion in the visual and vestibular perceptions will be a source of discomfort (nausea or vertigo).

The foot is the interface between the body and the ground. Input from the foot is mixed. Baroreceptors in the soles of the feet capture information concerning the type of ground (texture, grip, and gradient) in addition to the position of the foot so that it adapts to the ground. It also registers overlying constraints exerted by the body toward the ground.

The skin provides sensory information (pressure, stretching, and tension) in addition to nociceptive and thermal information.

In addition to these major inputs, there is somesthetic information (muscles, tendons, and joints). Striated muscles and neuromuscular spindles (starting point of the myotatic reflex) measure the length and variation in the length of the muscle and consequently, the tension exerted by muscle contraction. The Golgi tendon organ is a sensor located in the muscle tendons. The stretching of its collagen fibers causes autogenic inhibition reflex. Thus, the ankle, through its joints and the muscles and tendons of the posterior compartment of the leg (soleus muscle), informs the body's position with respect to the foot. The cervi-

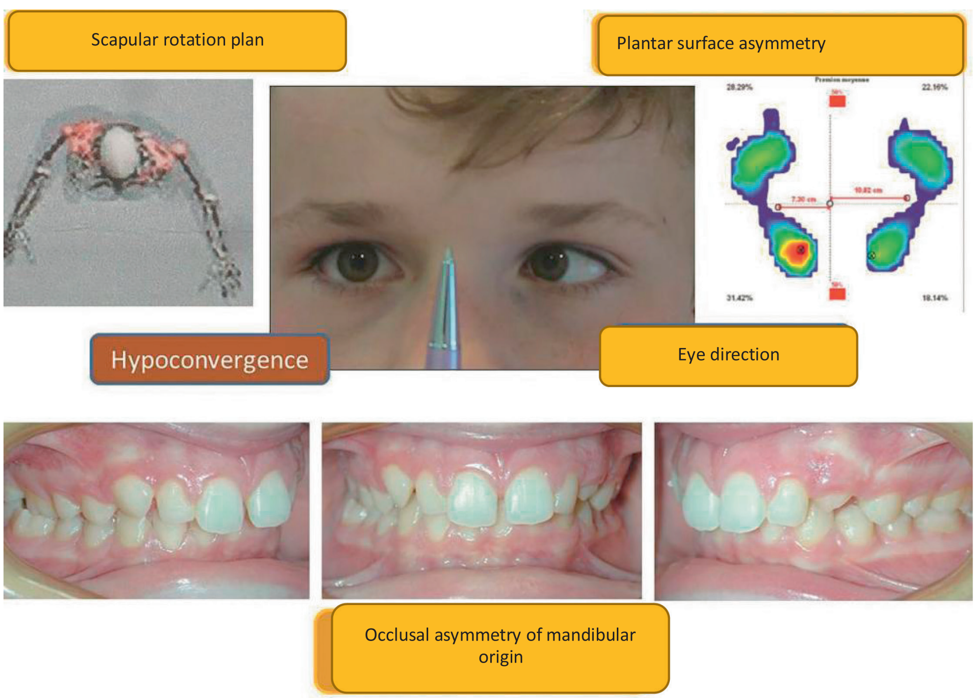

Figure 4
Clinical case. Test for ocular convergence. The results of difference in behavior between the eyes.

cal musculature, particularly the suboccipital muscles are rich in proprioceptive receptors, making it possible to know the head's position in relation to the body, which is essential when interpreting visual and vestibular information that only concern the head[34,29]. The pararachidian muscles and cervical and lumbar joints are a rich source of proprioceptive information. Knowing the stability of the pelvis is the primary component of postural balance when walking.

Similarly, the stomatognathic system is involved in posture because of its complex anatomical connections and neurophysiology. The manducatory system contributes its share of sensitive information. This is partially achieved by way of proprioceptive receptors located in the joint capsule of temporomandibular joints, which provide information concerning the horizontality of the head, an important element in oculo-labyrinthine stabilization. The periarticular muscles and mechanoreceptors of the periodontal ligament and hyoglossal chain[21,28] are other sensors. The tongue's sensitivity is extremely precise, and its distal subhyoid insertions create links to various body segments. The trigeminal nerve (V) plays a crucial role in the proprioception of the manducatory and oculomotor muscles. Its connections with the vestibular nerve (VIII) and its interconnections with the neck nuclei (C1, C2, C3, and spinal cord) make it an essential element of cephalic stabilization. Some authors[8] refer to the trigeminal nerve as the posture nerve.

Central Coordination

All information coming from different inputs benefits from central coordination. The system now has the ability to select pertinent information and reject useless information. Different structures come into play. The brainstem nuclei regulate the muscle tone, but more specifically, they are responsible for storing the muscles memories created. Reticular formation regulates postural tonicity, and the cerebellum adjusts movement. Motor sensory skills are then developed (fig. 5).

At the end of the postural system

Upon exiting the postural system via the extrapyramidal pathway, we encounter the musculoskeletal system. This acts as an effector as it makes use of tonic or phasic muscular activity or joint mobility. The vestibular nuclei leave the vestibular–oculomotor pathways, and this stabilizes vision when the head is moving or else stabilizes the image if the environment is mobile. The vestibulospinal tract maintains the body's position, irrespective of the position or movement of the head. The cervical musculature stabilizes the head's position to maintain the horizontality of vision, the inner ear, and the occlusal plane. This is necessary to continue receiving coherent information. The ankle and foot will cushion pressures coming from the overlying body segments and the ground.

When one decides on voluntary movement, the brain conjures up an internal representation (central to the corporeal schema in the spatial frame of reference) as well as motor models that have been preprogrammed by the feedback control[19] system in the preceding phases. It will then trigger the activation of the postural system so that all body segments are well positioned in relation to each other in an attempt to guarantee the correct progression of movement. During the execution of action, the feedback control system works to regulate and record the motor schema (fig. 5).

If any external imbalance appears or if there is any inconsistency in the information collected, postural adjustment mechanisms are put in place. Rapid reflex loops aid motor functions. If these phenomena persist, akin to proprioceptive imbalance or a change in the internal frame of reference, the cortical representations of the corporeal schema or the quality of motor models will be altered. The fact that the different structures of the postural system are inter-related at first allows the body to compensate for imbalances, which, in time, will result in an alteration of anatomical structures (even distant ones) if there is no correction. The progressive development of a postural disorder causes pain due to significant pressures on joints or the overcompen-

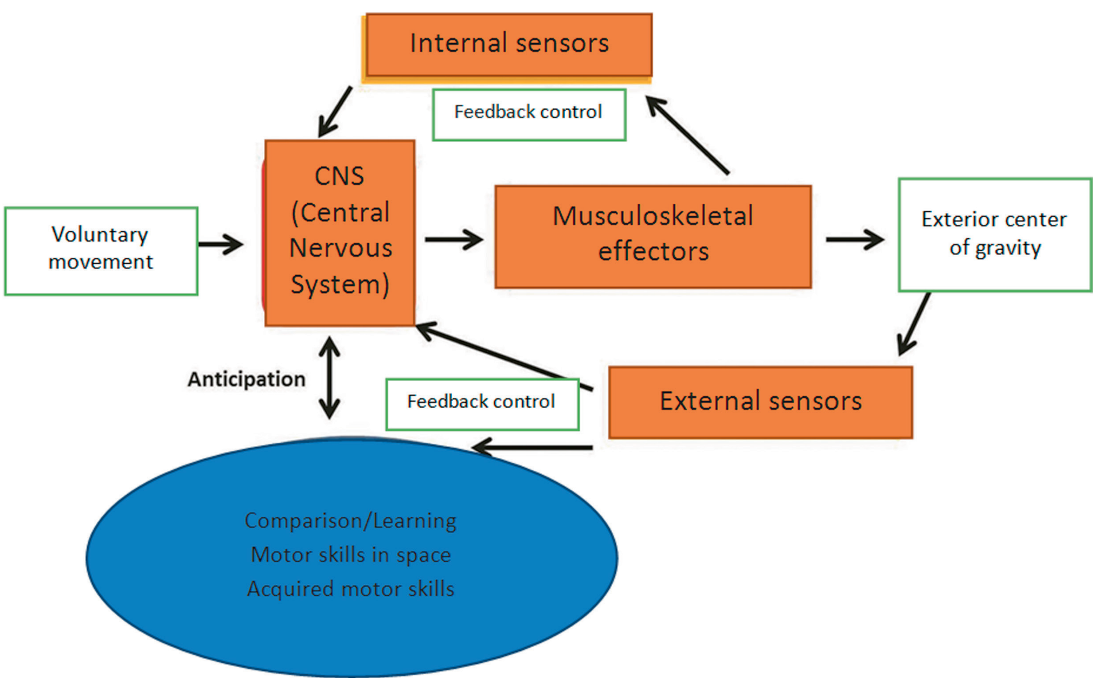

Figure 5
Sensory integration and postural control circuit.

sation of muscles and ligaments. The qualitative aspect of movement is also altered due to the loss of precision and fatigability.

During analysis and postural treatment, the difficulty lies in analyzing an old chart showing an ascending or descending trend. What is the initial dysfunctional element? What needs to be treated? This is the advantage of multidisciplinary treatment: it is able to provide the patient with the best possible care and to have a general, transverse vision of the patient.

PRESURGICAL POSTURAL DIAGNOSTIC ASSESSMENT

Orthognathic surgery is generally recommended to correct large intermaxillary or maxillofacial discrepancies.

It therefore generates a relatively large displacement of the centers of gravity of the displaced parts, which is a modification of the activity of the various muscle groups due to technical movements (disintegration) or skeletal displacements (stretching). Surgery also facilitates cervical and cervico-cranial joint reorganization and the need for functional adaptation (labial, lingual, ventilatory etc.). Similarly, sleep, ENT, and cardiac assessments may be required before any orthognathic surgery. Orthopedic (clinical or radiological), podiatric, orthoptic, or postural assessments may be necessary and should be reasonably systematized.

Examination

Postural diagnosis should be based on the analysis of data collected from an examination, which may reveal a disorder. The symptoms described can be pains at a certain distance from the manducator apparatus (neck pain, back pain, coxalgia, migraine, tendinopathies, recurring sprains, or fasciitis) postural instabilities (overall imbalance, sensation of misalignment, dizziness while walking, loss of precision in movement, etc.), and cognitive symptoms (headaches, pseudo-depressive syndrome, and difficulty concentrating.)

Morphostatic Analysis

The morphostatic analysis of the face, profile, and back against a vertical line is an important treatment phase.

The spinal curves are examined (fig. 6), in addition to the valgus or varus, alignment of the pelvic and scalpular belts, posterior plane of the scapulas, thoraco-bronchial angles, spontaneous position of the head inclination, and rotation (fig. 7 and 8).

The analysis must detect specific plantar surfaces and a possible short lower limb. It is also wise to incorporate qualitative analysis of a person's walk (fig. 9).

Postural Tests

There are many postural tests,[5] but we opted to present the most conventional ones that would easily allow us to demonstrate a postural syndrome and to guide the diagnosis.

Romberg's test: The patient stands with feet together, eyes closed for 20 s, and arm and index fingers outstretched. In the absence of a pa-

Figure 6
Screening for scoliosis. Non-alignment of the vertebrae in the standing position. Dorsal protuberance apparent in ventral flexion.

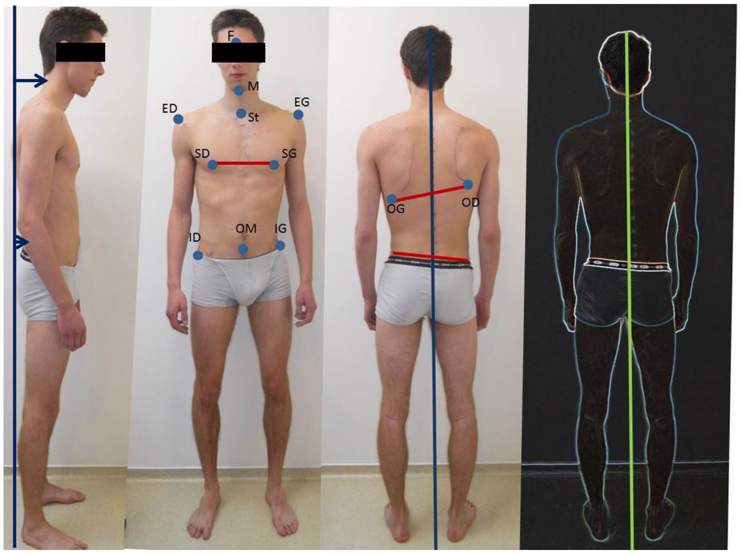

Figure 7
Profile: reduction of the vertebral curves, deepening of the cervical spine, and forward inclination of the head. Severe discrepancy. Front: alignment of the front, chin, sternum, and umbilical points. Inclination of the iliac plane (Ig-Id) in the lower right. Horizontality of the scapular plane (Eg-Ed). Head tilted toward the right. Back: inclination to the lower left of the shoulder plane, decentering of the vertical of Barré (normally passing by the vertex, C7, and gluteal fold). Anterior rotation on the right side of the pelvis.

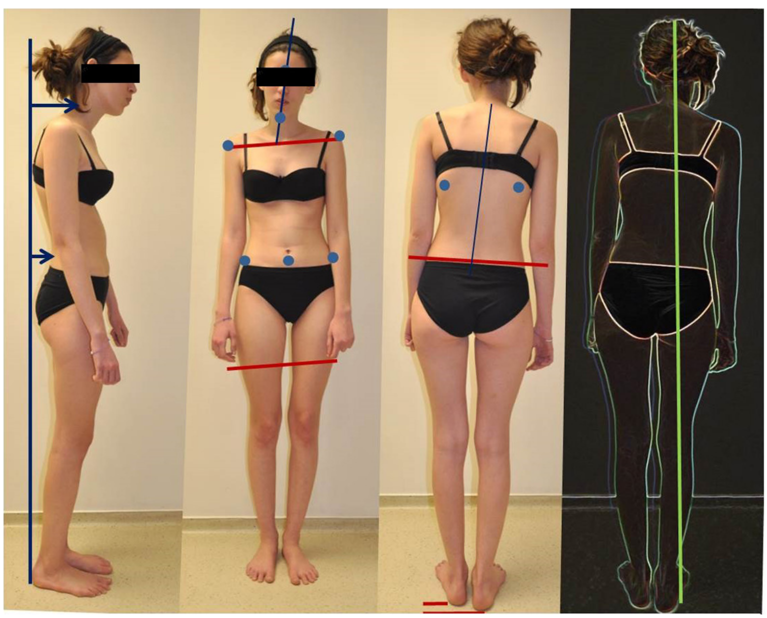

Figure 8
Profile: accentuation of vertebral curves (thoracic hyperkyphosis) and the cervical spine, anterior inclination of the head. Mandibular retrognathia. Front: non-alignment of the forehead, chin, sternum, and navel. Inclination of the shoulder plane and iliac plane to the lower right. Facial asymmetry. Back: decentering of the vertical Barré. Inclination of the spine to the right compensation of the head inclined to the left. The left foot is more anterior.

Figure 9
Anterior rotation of the pelvis on the left side. Lower right inclination of the scapular plane. External left foot opening angle. Occlusal asymmetry.

thology, the patient will not fall. If they maintain their balance well, the labyrinth and proprioceptive pathways are functioning properly. If not, any fall, any deviation, or substantial oscillation of the trunk can signal a vestibular impairment on the side of the deviation. A unilateral or bilateral deviation of the index fingers can indicate central or peripheral damage (fig. 10A).

The Fukuda test: This test requires the patient to stomp blindly. The patient takes 50 steps in a quiet room with eyes closed and arms extended at a 90°. The teeth are not occluded. If the patient presents a deviation that rotates on itself and is greater than 30°, the test is positive. It can also be done by turning the head, and usually, the deviation is physiologically manifested on the opposite side of the cephalic rotation. It would be useful to highlight a vestibular neurological impairment (fig. 10B).

To test the visual input, the convergence should be tested. The patient is asked to focus on a point that progressively moves closer to the nose, and the deflection of the eyes is evaluated. Normally, the two eyes squint in the same way (fig. 4).

To test the *impact of the orofacial system*, the Heron test can be used. The patient remains standing on one foot for 20 s and then alternates with the other foot. The occlusal input (stabilization contraction) and oculomotor receptors are tested by this exercise.

As a general rule, for the masticatory receptor, we tend to record the body's projection on the platform[12] when the occlusion is at the center of gravity and then compare this result to the results obtained when a little wedge is inserted into the premolomolar sector during a test for dental occlusion, when the lips are together, and the tongue is in proper resting position. If there is a difference, the manducator apparatus could be interfering with the postural balance. However, the stabilometric analysis is relatively difficult to correctly perform and reproduce (fig. 11).

Analyzing tone, posture, and lingual proxies (functions associated with swallowing, chewing, ventilation, and phonation) inform us of the postural impact of the hyoglossal apparatus. Evaluating the difference in the size of cervical rotation in maximum intercuspation and in occlusion allows us to see the impact of the occlusion on cervical mobility (fig. 12).

The example of facial asymmetries is very indicative of this multifactorial diagnostic set. Multiple etiologies can still frequently have their origin in a regional postural disorder (congenital torticollis, dominant eye, etc.), the repercussions of which may extend to the rest of the body such as downlink (fig. 4) or on the contrary may develop into an ascending postural disorder such as scoliotic attitude, scoliosis[27], pelvic obliquity, femoral head rotation, and true short leg syndrome and even asymmetry of the plantar surface (fig. 13A).

Figure 10
A. Romberg Test B. Step test by Fukuda.

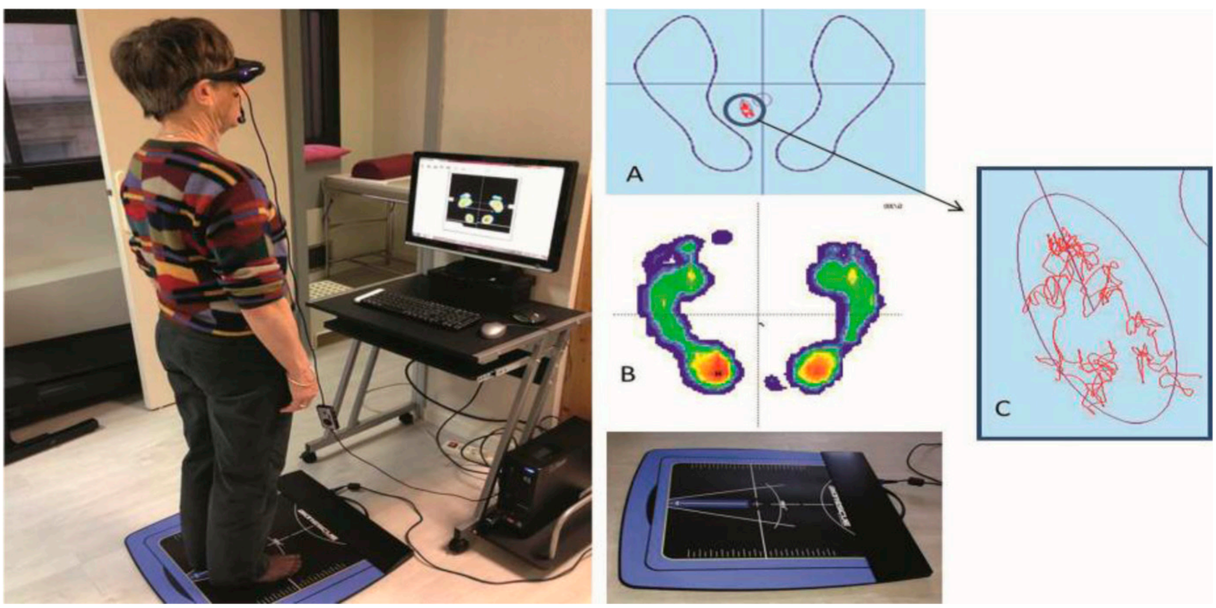

Figure 11
Postural recording on a stabilometric platform. Situating the projection to the floor of the body's center of gravity (equivalent center of pressure COP) in the foot support frame. Statokinesigram (the amplitude of the distance of the COP). Plantar pressure analysis.

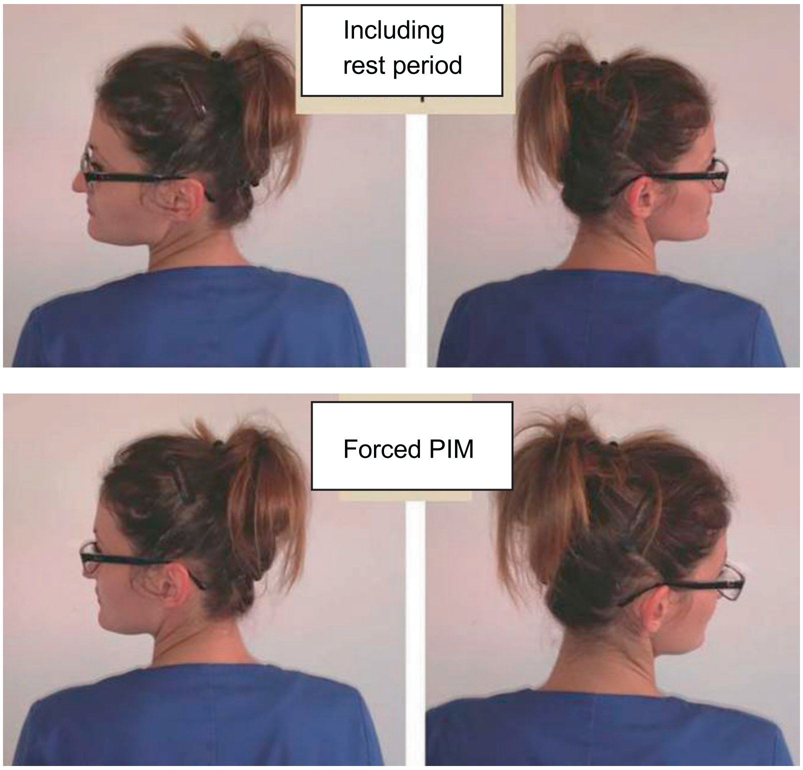

Figure 12
Head rotation test. The rotation PIM is smaller on the right side, suggesting an influence of occlusion on cephalic posture.

CONCLUSION

The various clinical examples used in the preceding paragraphs show how important it is for a patient to be perceived as a whole. It is essential to factor their postural balance in the etiology of their dysmorphoses as well as to determine how it will affect their treatment. It should prevent us from being iatrogenic with patients presenting a postural risk, and it helps increase the stability of corrections made. Through a multidisciplinary and more global approach, other pathologies that were not previously associated can be reduced. This is where orthognathic surgical treatments come into play (fig. 13).

Conflicts of interest: The authors have declared that they do not have any conflict of interest.

Figure 13

A. Presurgical examination. Hyperdivergent class III malocclusion with right mandibular alterations. Scoliotic attitude at lumbar inception with a change in curvature at the thoracolumbar junction. Lower right obliquity of the scapular plane. B. Postsurgical examination at 1–5 months. Alignment and verticality of the vertebral columns. Scapular plane horizontal and perpendicular to the vertebral column. Symmetrical positioning of the shoulder blades. Correction of facial dysmorphoses. C. Stability of the postural correction at 12 months.

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