TMJ internal derangement treatment in the growing patient: effect of functional appliance therapy on condyle and fossa relocation

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New biodynamic factors seem to be involved on condyle and fossa remodeling and relocation, conditioning to mandibular growth direction, size and morphology. The understanding of the mechanism of action is critical for treatment of TMJ dysfunction in children and youths for those who hope to treat and retain the achieved correction during growth. The purpose of this article is to describe a specific, non-muscular hypothesis that explains the way the condyle modifies and the fossa remodels and relocates to achieved a new therapeutic, stable position, creating an anatomical base for long-term retention of the results. A case report of a young patient will be illustrated and available clinical data will be discussed.

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INTRODUCTION

Our understanding of temporomandibular disorders (TMD) is growing, and the expanding diagnostic knowledge continues to call for new longitudinal studies focusing on the developmental basis of temporomandibular disorders. However, little is known about the influence of TM pathology or myofascial disorders on facial growth. Also, little is known about the possible influence of disc interferences on facial growth.

The purpose of most of the studies describing condyle-glenoid fossa growth modification is to understand the mechanism involved on condyle and fossa remodeling in the production of a real, significant bone formation with repercussions on mandibular growth and facial form. Interpreting literature on this modification can be challenging, mainly because of the variation in the study design and analyses. Over the years, several theories have emerged attempting an explanation on TMJ growth and remodeling. One of the earliest ones, the **genetic theory** suggests that the condyle is under strong genetic control, although this theory may be related more to the development of the prenatal than postnatal condyle.[1]

A second hypothesis based on earliest available EMG monitoring technique, suggests that hyperactivity of the lateral pterygoid muscle (LPM) promotes condylar growth.[2,3] More recently, permanently longitudinal muscle monitoring techniques have found that condylar growth is actually related to decreased postural and functional LPM activity. The **LPM hyperactivity theory** was, none-the-less, important in promoting further investigations in muscle-bone interactions.

Hypothesis termed **the functional matrix theory** postulates that the principal control of bone growth is not the bone itself, but rather the growth of soft tissues directly associated with it.[4-6] Although this was supported by investigations testing the different growth and developmental responses of the condyle,[7-9] there has been no explanation as to exactly why condylar growth would be stimulated. Thus, the validity of this theory has been questioned. One of the reasons was that there was little explanation about the specific mechanism by which the condyle was stimulated to grow.

Enlow and Hans[10] presented an excellent overall perspective suggesting that mandibular growth is a composite of regional forces and functional agents of growth control that interact in response to specific extracondylar activating signals.

Finally, the **growth relativity hypothesis** refers to growth that is relative to the displaced condyles from actively relocating fossae.[11,12] According to this theory, the glenoid fossa promotes condylar growth: initially,

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that displacement affects the fibrocartilaginous lining in the glenoid fossa to induce bone formation locally. This is followed by the stretch of non-muscular, viscoelastic tissues (in this case, viscoelasticity refers to all noncalcified tissues, specifically the viscosity and flow of the synovial fluid, the elasticity of the retro-discal tissues, the fibrous capsule and other non-muscular tissues including LPM perymisium and TMJ tendons and ligaments). The concept that viscoelastic tissue forces can affect growth of the condyle suggests that the condyle is affected by the posterior viscoelastic tissues anchored between the glenoid fossa and the condyle, inserting directly into the condylar fibrocartilage. Anterior orthopedic displacement of the condyle and the stretching of the viscoelastic tissues further stimulate condylar growth by the transduction of forces over the fibrocartilage cap of the condylar head. The difference between the growth relativity hypothesis and the functional matrix theory is that the former is specific to the condyle-glenoid fossa and identifies the soft tissues, fluids and loci of force transduction that cause growth modifications and involves numerous intrinsic and extrinsic interactions. These interactions include electrophysiological and neural sensory factors, oxygen tension, hormonal and nutritional aspects. New recent perspectives have focus the attention on the action of new biological factors involved in the dynamic of the TMJ, which might be responsible for key processes governing condylar growth.[13] Among the others, Sox-9 seems to play an important role as regulator of chondrocyte differentiation and type II collagen, the major component of the cartilage matrix during forward mandibular positioning. This could open new perspectives in TMD treatment in youths and children and long-term results. In fact, the question whether condylar growth can be enhanced and modified to a significant degree, must always be quantified in terms of time: this is because, in the past, the clinically significant results of short-term treatment[14] have been shown to be quite different from the fmdings on long-term stability.[15]

The aim of this article is to discuss the up-to-date known mechanism involved in condylar growth and glenoid fossa remodeling and relocation in growing beings. A case report of TMD developed after orthodontic treatment will be illustrated and the different steps of the therapeutic strategy will be discussed.

CASE REPORT

The patient presented at the age of 14 years 6 months with joint symptoms characterized by temporo-mandibular joint pain and disc displacement with reduction. Symptoms had begun six months after the extraction of the last second bicuspid, followed by fixed orthodontic treatment. The appearance of a single click in both TMJs had been followed in a few weeks by a reciprocal click. In three months TMJ noises disappeared, while restrictions in mouth opening (down to 20 mm) and deviation to the left became more and more evident. After that, two episodes of locking occurred at night were referred. On that occasion, the patient had been awakened by pain and reduction had been obtained with difficulty by manipulation. Inspection revealed an apparent mild deviation of the chin to the left combined with marked deviation to the left during mouth opening (Figure 1).

The intra-oral inspection put in evidence a first molar class I bilaterally. (Figure 2). The patient did not complain of facial pain, but referred to masticatory muscles tenderness to palpation bilaterally. Tenderness was present in TM joint regions, particularly on the left.

Panoramic radiography (Figure 2) and the postero-anterior cephalometric projection did not show any altered bony anatomy. Magnetic resonance imaging (MRI) showed an anterior dislocation of the disc on both sides when the patient occluded into maximum intercuspal relationships and during mouth opening (Figures 3a, 3b).

The patient was immediately scheduled for anterior repositioning therapy by means of functional jaw orthopedic (FJO) appliances. This was to favor an anterior sliding of the mandible as close as possible to the position allowing disc reduction. The patient was instructed to wear the appliance as much as possible, particularly at night. One week later, mouth opening had increased up to 32 mm. The position obtained with the appliance was then checked by MM (Figure 3c).

Seven months later, mouth opening, protrusion and lateral excursions showed a normal range (Figure 4). A new magnetic resonance imaging (MM) was performed and showed the bilateral re-establishment of normal condyle-disc relationships into maximum intercuspal relationships (Figure 5a) and during mouth opening (Figure 5b). At that time, the patient was scheduled for fixed appliance therapy to stabilize the new occlusal relationships. At the same time, she was instructed to use the appliance only at night.

Eighteen months after the beginning of treatment no subjective symptoms and/or objective signs of TMJ dysfunction are present, no facial asymmetry can be noticed and occlusion is normal and stable. Mouth opening is 32 mm with no deviation (Figure 6). The girl is not in treatment anymore, but is still under observation.

DISCUSSION

In the case report illustrated above, temporo-mandibular disorders seemed to be relayed to the extraction of bicuspids. In general, extraction of bicuspids must always be carefully evaluated because of reduced lip support and poor facial profile. Furthermore, the usual orthodontic treatment sequence following extraction causes reduction of the premaxilla, forces the condyle into a superior-distal position causing a reduction of

Figure 1. Frontal and lateral photographs: an apparent mild deviation of the chin to the left combined with marked deviation to the left during mouth opening is evident.

Figure 2. Panoramic radiography : no altered bony anatomy is present. The intraoral view puts in evidence a first molar class bilaterally.

the retro-condylar space. The consequence is a reduction of blood flow to the head and neck and pressure on the trigeminal nerve. Furthermore, most bicuspid extractions occur at the age of 12 years and facial growth is not complete until 16 to 18 years of age.

Anterior repositioning therapy by means of functional jaw orthopedics (FJO) is the elective treatment of these cases.[16,17] The main focus of the technique is concerned with the concept of the so called "Geib 4/7" position of the condyle in relation to the outline of the glenoid fossa. It is a position correlating to the physiologically normal condylar position in healthy normal human TM joints. Geib described this position of the condyle in the fossa, which allows the necessary space for the healthy function of the TMJ.[18] In other words, there is a critical 3 mm space necessary above the head

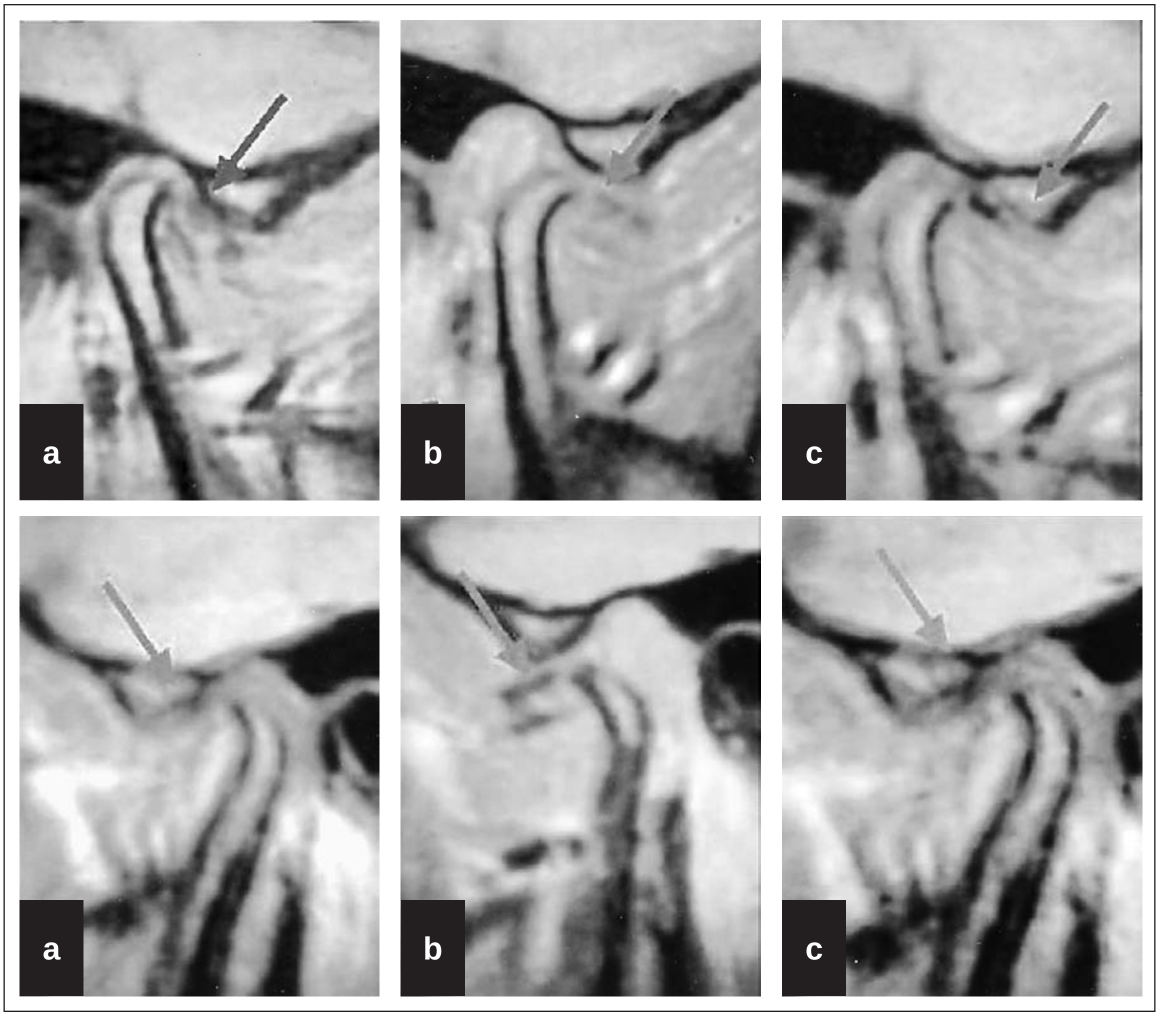

Figure 3. Magnetic resonance imaging (MRI): an anterior dislocation of the disc on both sides when the patient occluded into maximum intercuspal relationships (Figure 3a) and during mouth opening (Figure 3b) is evident. The position obtained with the appliance was then checked by MRI (Figure 3c).

of the condyle in the fossa. The posterior vs. anterior chamber should be a 3:1 ratio as the retro-condylar space is the most critical allowing for the compression of the delicate post articular connective tissue during mastication. In this way, the TMJ and surrounding structures have the necessary space for normal function. The rational for mandibular anterior repositioning is to diminish temporo-mandibular joint pain by decreasing adverse loading, soft tissues noises and myofascial discomfort. For these reasons, the posteriorly displaced condyle must first be "decompressed" via mandibular advancing FJO techniques. This was what we did by means of functional advancing appliance therapy to a position as much close as possible to that allowing disc reduction. The patient was instructed to wear the appliance as much as possible during the day and at night.

In one week, TMJ and masticatory muscles tenderness disappeared and mouth opening increased up to 32 mm. The patient did not have any discomfort in using the appliance. At this point, the condylar position was checked by magnetic resonance imaging (MM) and then the patient was routinely checked once a month.

Seven months later, mouth opening, protrusion and lateral excursions showed a normal range, no pain was found, but occlusal relationships were critical. This was due to the fact that mandibular anterior repositioning would most definitely alter occlusal, functional and muscular relationships. So the existing pre-treatment occlusion must be modified as to provide a functional new occlusion that supported and maintained that correct condylar relationship in the pain-free, normal articular position. This step of treatment was aimed at protecting the formerly damaged postcondylar bilaminar zone. For this reason, the patient was scheduled for fixed appliance therapy and was instructed to wear the functional appliance only at night.

Evaluation of long-term changes in the condyle-fossa relationship that take place in the condylar distraction associated with mandibular anterior

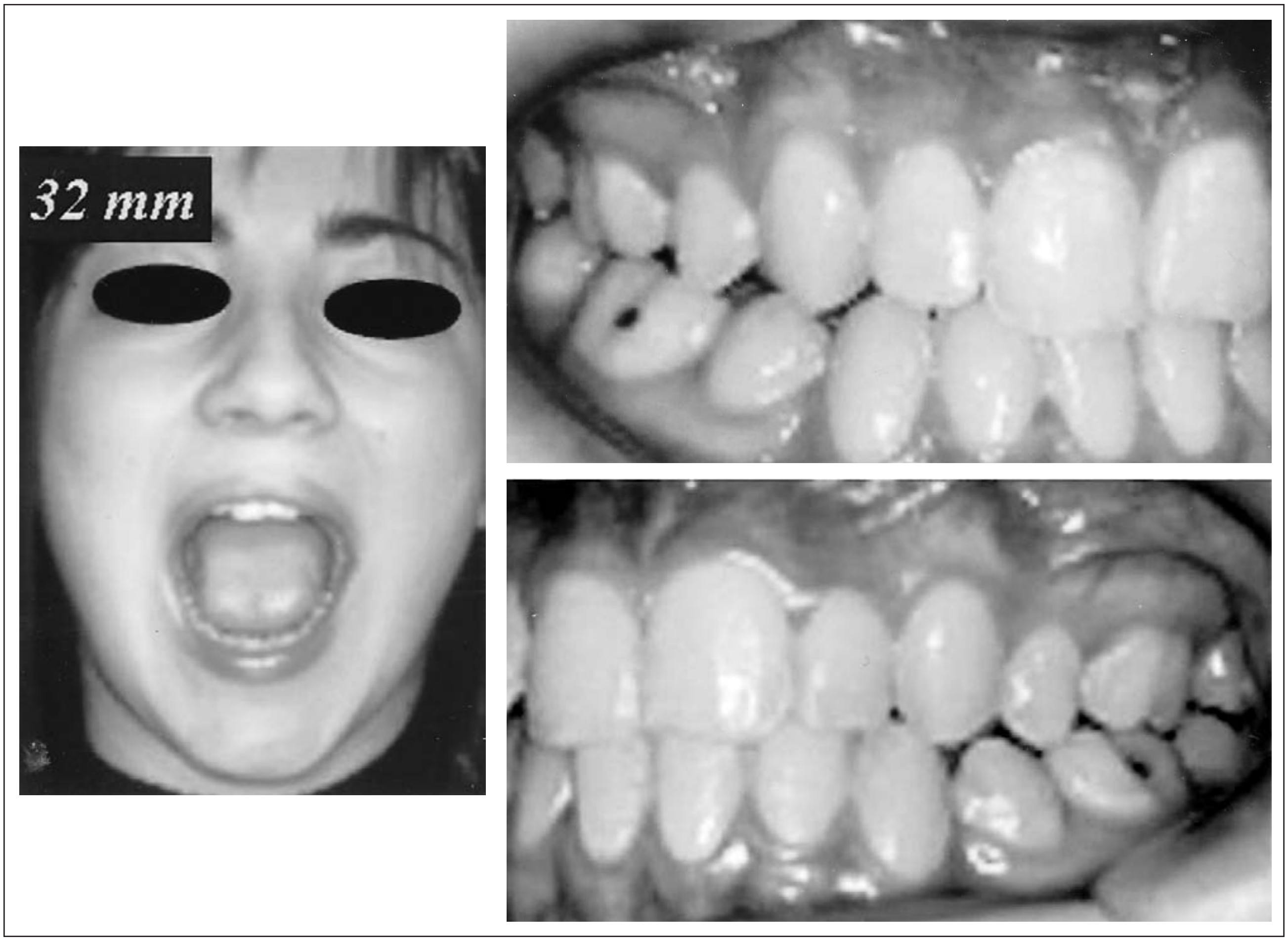

Figure 4. Seven months later, mouth opening was 32 mm. Intraoral views show new occlusal relationships.

repositioning is critical. Results are quite different in adults compared to the growing patient. In adults, as the functional environment attempts to re-establish equilibrium through adaptation, there is a high likelihood of relapse. In the growing patient, a real relocation of the condyle-fossa unit due to true remodeling of the TMJ takes place.

In fact, according to the **growth relativity hypothesis** mentioned previously, orthopedic mandibular advancement enhances an influx of nutrients and other biodynamic factors into the region through the blood vessels of the stretched retrodiscal tissues that feed into the fibrocartilage of the condyle. The expulsion of these factors occurs during reseating of the displaced condyles in the fossa during relapse. This results is a metabolic pump-like action of the retrodiscal tissues.[19] Furthermore, the low intra-articular pressures is significant in altering the joint fluid dynamics of synovial fluid.[20] It was observed surgically that these negative pressures shift synovial fluid perfusion in a posterior displaced direction. These negative pressures, initially below capillary perfusion pressures, permits the greater flow of blood into the condyle-glenoid fossa region. This increases the flow of the synovial capillaries near the condyle and the fossa.[21] Forward mandibular positioning accelerates and enhances chondrocyte differentiation and cartilage matrix formation in the mandibular condyle by accelerating and enhancing the expression of growing factors like Sox 9 and type II collagen.[13] This represents the biological basis for normal growth process and may result in long-time stable results. This enhancement of growth seems to be stable, and not a result in a mere, subsequent pattern of subnormal growth, indicating so true growth process TMJ codyle-fossa remodeling gives stable results after condylar temporary anterior relocation obtained by mean of different appliances.[13]

As far as the case described is concerned, eighteen months later no subjective symptoms and/or objective signs of TMJ dysfunction are present and occlusion is

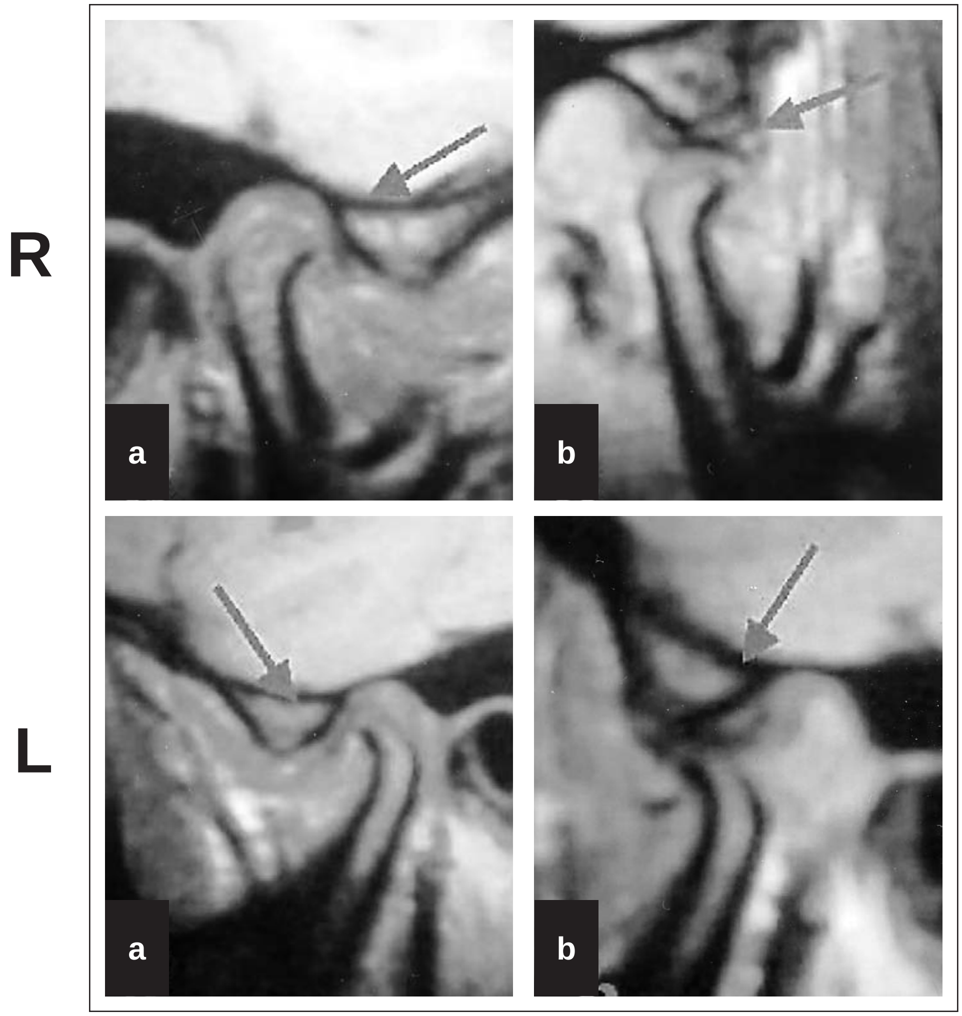

Figure 5. MRI show the bilateral re-establishment of normal condyle-disc relationships into maximum intercuspal relationships (Figure 5a) and during mouth opening (Figure 5b).

normal and stable. Magnetic resonance imaging (MRI) supports the condyle-glenoid fossa remodelling with the bilateral restoration of the functional unit of the disk and the condyle both in static and dynamic conditions. The girl is still under observation.

Anterior repositioning therapy by means of functional jaw orthopedics (FJO) is now becoming recognized as a valid treatment technique for correcting TMJ internal derangement.[16,17] The main focus of the technique is concerned with the concept of the "Geib 4/7" position of the condyle in relation to the outline of the glenoid fossa, a position that appears somewhat off center, down and forward in the fossa at full occlusion. And it has now been shown that the delivery of a condyle that is posteriorly displaced from this position and is consequently functioning off the disc, back down and forward once again by anterior repositioning therapy techniques has an extremely successful percentage of stable displaced disc recapture.[22] This is a valuable procedure not only for the elimination of symptoms, but also for the prevention of further degeneration of the joints through a steadily progressive continuum ending in a state of "clinical closed lock" or even blatant avascular necrosis and regressive remodeling of the condylar head with its attending facial and stomatognathic deformations.[2] Much research has been reported concerning the development of the mandible, specifically the mandibular condyles.[19] The studies must also be distinguished between those conducted on human beings and animals. Animal studies must always be considered critically. First of all, TMJ anatomy is different to humans, and besides, animals have a different direction of growth and different growth patterns to humans. Retrospective studies have the following concerns: lack of proper controls, records that are not comparable, difficulty in obtaining homogeneous samples.

Information relating to the normal development, growth, and adaptation of the temporomandibular joint all tend to emphasize the significant ontogenetic plasticity of the growth-related secondary cartilage associated with the TMJ, within the bounds of normal function and histophysiology. As a result, FJO oriented techniques

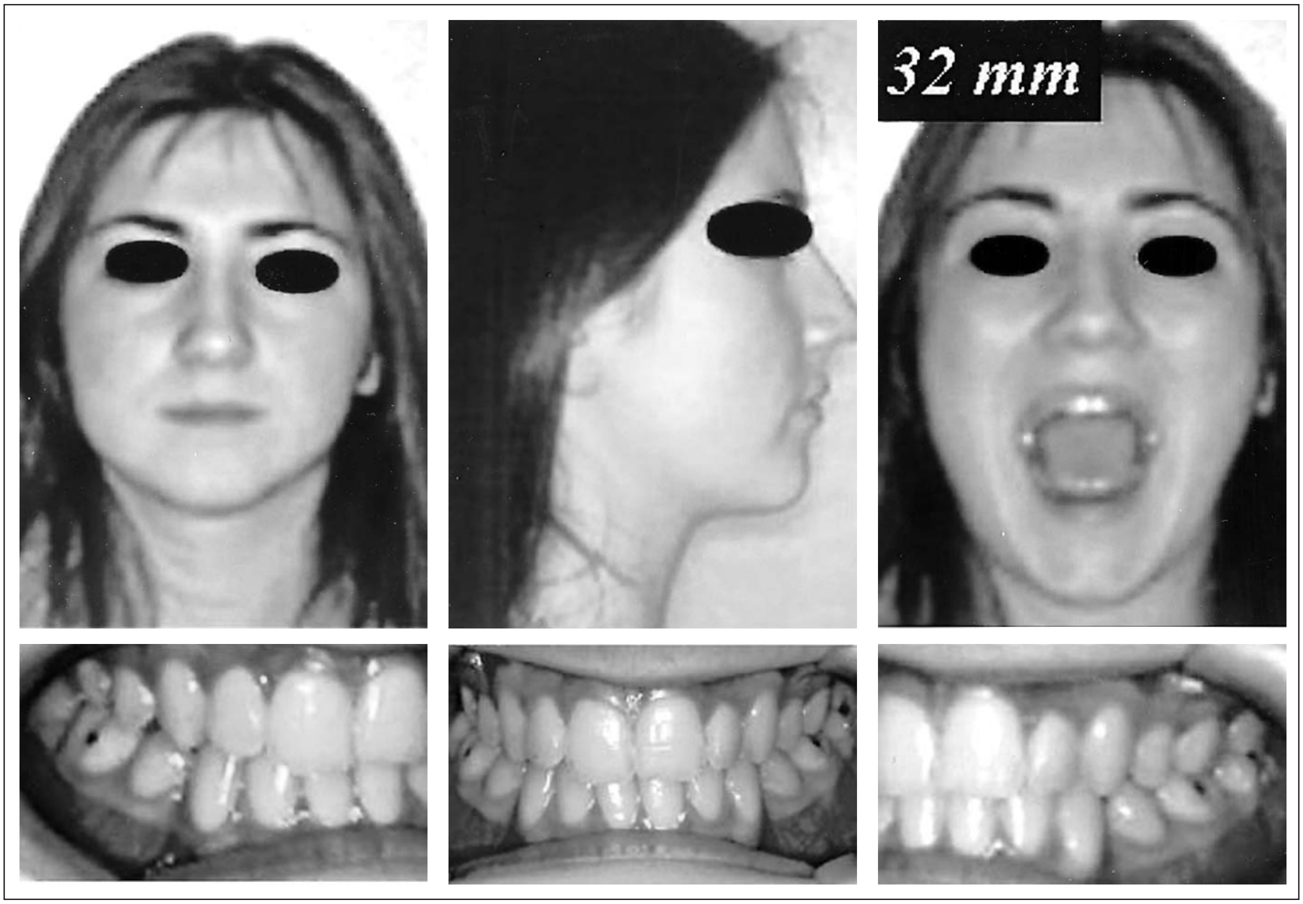

Figure 6. No objective signs of TMJ dysfunction are present, no facial asymmetry can be noticed and occlusion is normal and stable.

that advance the mandibular/condylar unit forward and produce an altered occlusion that re-establishes normal maxillo-mandibular and condyle/fossa functional (decompressed) relationships in turn will be found to relieve these problems almost invariably provided proper "follow-up" treatment is employed.

The glenoid fossa and the displaced condyle are both influenced by the articular disc, fibrous capsule, and synovium, which are contiguous, anatomically and functionally, with the viscoelastic tissues. Therefore, condylar growth is affected by viscoelastic tissue forces via attachment of the fibrocartilage that blankets the head of the condyle. Microscopic examination of TMJ sections has revealed direct connective tissue attachments of the retrodiscal tissues into the fibrocartilaginous layer of condylar neck. Once anterior repositioning therapy has successfully secured the Geib 4/7 functional condylar position, all that remains for completion of the case is the enlistment of orthodontic procedures to duplicate as near as possible the temporary splint-occlusion with a "natural" occlusion that will support and preserve that functionally corrected condylar position and prevent its return to the posteriorly displaced, deranged position, off the disc.[24]

Anterior repositioning appliance therapy disc recapture technique are very efficient in treatment of condyles posteriorly displaced with the respective disc correspondingly anteriorly displaced (torn loose and displaced over the front of the condylar head). Therefore, proper corrective treatment consists of relocating (repositioning) the condyles down and forward to the original GeIb 4/7 pain relieving areas of the joint once again and holding them there in both rest and function until the joint stabilizes (heals), followed by building a stable occlusion to permanently keep them there again, during both rest and function.

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