ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 12, Issue, 10, pp.14358-14362, October, 2020

DOI: https://doi.org/10.24941/ijcr.39994.10.2020

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

RESPONSE TO TWIN BLOCK TREATMENT: A LITERATURE REVIEW

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ARTICLE INFO

Article History:
Received 29th July, 2020
Received in revised form
17th August, 2020
Accepted 19th September, 2020
Published online 30th October, 2020

Key Words:

Twin Block, Myofunctional Appliance, Mechanism of Action.

ABSTRACT

Myofunctional therapy has been widely used for correction of developing Class II malocclusion. Since its inception various concepts about its mechanism of action has been proposed and investigated. However, not a single theory has been widely recognized. This review is an attempt to evaluate and compare all the theories described in orthodontic literature regarding working mechanism of myofunctional therapy in general and twin block appliance in particular. Subject Area: orthodontics and dentofacial orthopedics Keywords: myofunctional appliance, twin block, mechanism of action.

Citation: ***Dr. Sheetal Jankare, Dr. Prafull Parchake and Dr. Sachin Katole.*** **2020.** "Response to Twin Block treatment: a Literature Review", *International Journal of Current Research*, 12, (10), 14358-14362.

INTRODUCTION

Since the twentieth century, functional appliance therapy has become a generally accepted method to treat moderate to severe sagittal discrepancies in children with its greatest application and success in the treatment of Skeletal Class II malocclusion. The theoretical basis for functional appliance therapy, in general, is the principle that "new pattern of function" dictated by the appliance, leads to the development of correspondingly "new morphologic pattern." The "new pattern of function" can refer to different functional components of the oro-facial system-for example, the tongue, the lips, the facial and masticatory muscles, the ligaments, and the periosteum. Depending on the type of appliance, its proponent puts more emphasis on one of these different functional components. This "new morphologic pattern" includes a different arrangement of the teeth within the jaws, an improvement of the occlusion, and an altered relation of the jaws. It also includes changes in the amount and direction of growth of the jaws, and differences in the facial size and proportions (Carine Carels, 1987). Historical evidence suggests that facial sutures were influenced as early as 1803 by application of extraoral force. Wolf (1873) stated 'trajectoral theory' according to which trabeculae of cancellous bones are oriented along the lines of principle stress. This theory highlighted one important concept of the relationship between Form and Function (Harold, 1994).

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Twin block invented by Dr. William Clark in 1978 has gained widespread popularity from its inception and till now considered as most popular removable functional appliance. It works on a principle of occlusal inclined plane which is formed by the cusps of upper and lower teeth which forms a servo mechanism that locks the mandible in distally occluding functional position. These planes form an important part in determining the relation of the teeth as they erupt into occlusion thereby creating a fundamental functional mechanism of natural dentition. A series of growth studies have been done on monkeys and rodents to study the effect of occlusal inclined planes. The results of these studies indicate that the functional mandibular protrusion with inclined plane has a profound effect on the whole of the dental arch, condylar head, glenoid fossa and the muscle attachments. Even in adult animals, the whole stomatognathic systems including the soft tissues adapt to establish an efficient masticatory system. The clinical response observed after fitting twin blocks is closely analogous to the changes observed in animal experiments using fixed inclined planes.

Harvold demonstrated in animal experiments that when the mandible is advanced, a "tension zone" is created above and behind the condyle. This is an area of intense cellular activity quickly invaded by proliferating connective tissue and blood capillaries, within a few hours or days (Harold, 1994). Mc Namara described "pterygoid response" where the patient finds it difficult to retract mandible into its former retruded position which is due to compression of connective tissue and blood vessels leading to ischemia (Rabie *et al.*, 2002).

Vascular Endothelial Growth Factor: (VEGF) is a potent regulator of neovascularization expressed during endochondral ossification of long bones as well as mandibular condyle. Chondrocytes in the mandibular condyle stimulate VEGF which stimulates neovascularization and marks the onset of endochondral bone formation. The expression of VEGF in the mandibular condyle increases upon forward posturing of the mandible, with the pattern of expression closely related to new bone formation. Mechanical load is an important regulator of chondrocyte metabolism and is necessary to maintain cartilage matrix properties. Changes in the degree or frequency of loading significantly affect the production of matrix molecules such as type II collagen and proteoglycans. Mandibular advancement leads to an increase in VEGF by the chondrocytes, which is the regulator of the process of recruiting new blood vessels into the hypertrophic cartilage matrix of the condyle. The newly recruited blood vessels deliver mesenchymal cells required to replenish the population size of the osteoprogenitor cells needed for differentiation into bone-making cells in order to replace the hypertrophic cartilage matrix in the condyle with bone. The invasion of new blood vessels into the hypertrophic cartilage matrix marks the onset of endochondral ossification (Rabie *et al*., 2001).

The process of differentiation of chondrocytes is regulated by Sox 9 transcription factor. Sox 9 is a high-mobility-group–type transcription factor that controls the differentiation of mesenchymal cells into chondrocytes by directly activating the gene expression for type II collagen. It is regulated by several factors such as fibroblast growth factors, tumor necrosis factor and bone morphogenetic protein-2 (BMP-2) that play important roles in craniofacial development and bone formation. Type II collagen that is synthesized by chondrocytes is the main type of collagen that forms the framework of the cartilage matrix in the growing condyle. After cartilage matrix formation, chondrocytes mature and hypertrophy. Hypertrophic chondrocytes secrete type X collagen, which marks the onset of endochondral ossification and the replacement of the hypertrophic cartilage matrix with bone (Voudouris, 2000).

Cellular response to mandibular protrusion-

Rabie *et al* examined cellular response following mandibular advancement with bite jumping appliance in Sprague-Dawley rats and found the amount of bone formation in the anterior, middle and posterior area of the glenoid fossa. The highest level of new bone deposition occurred in the posterior region of the glenoid fossa. In the fibrous layer, the fibroblasts were found to be packed parallel to the articular surface on day 3 and became increasingly oriented towards the direction of the pull by disc fibers from day 7 onwards. The fibroblasts were round at the beginning and were stretched and flattened by the mandibular protrusion. The mesenchymal cells beneath the fibrous layer were arranged in line with the articular surface on day 3. With the mandibular protrusion, however, the axis of the mesenchymal cells became increasingly aligned with the presumed direction of pull. In the cancellous bone layer, the osteoblasts and osteocytes were randomly packed at the beginning of mandibular protrusion. The identification of the temporal sequence of the cellular response revealed that the mesenchymal cells in the posterior region of the glenoid fossa were oriented in the direction of the pull. This might account for the enhanced bone deposition in this region during mandibular protrusion (Camilo Yamin, 1997).

Mechanism of action of Twin Block: Various theories have been proposed to explain the mechanism of action of inclined planes

Genetic theory: It suggests condyle is under strong genetic control like epiphysis of long bones. Although this may be related to prenatal rather than post-natal development of mandible, several long-term investigations actually showed clinically insignificant condylar growth modification after continuous mandibular advancement with a reasonable retention period in human being (Aggarwal, 1999).

Muscle hyperactivity theory: It suggests hyperactivity of lateral pterygoid muscles promotes condylar growth. Anatomically LPM tendon is attached to the fibrous capsule of TMJ which in turn attaches to the fibrocartilagenous layer of condylar head and neck. However, permanently implanted longitudinal muscle monitoring techniques have found that condylar growth is actually related to decreased activity of the lateral pterygoid muscle. Camilo Yamin *et al* (1987) studied electromyographic activity of masseter, digastric and superior and inferior head of lateral pterygoid muscles by chronically inserted EMG electrodes and found a decrease in EMG activity of all four muscles following insertion of functional appliance (Nitzan, 1994). Aggarwal *et al* (1999) found the increased activity of masseter and anterior temporalis muscle and concluded that this electromyographic increase in activity is due to the enhanced stretch (myotactic) reflex of elevator muscles.[13]

Functional matrix theory: It postulates that the principle control of bone growth is not the bone itself, but rather the growth of soft tissues directly associated with it. Although this was supported by investigations testing the different growth and developmental responses between the condyle and epiphysis, there has been no explanation as to exactly how condylar growth would be stimulated questioning its validity.

Growth relativity theory: The glenoid fossa promotes condylar growth with the use of orthopedic mandibular advancement therapy. Initially, that displacement affects the fibro-cartilaginous lining in the glenoid fossa to induce bone formation locally. This is followed by the stretch of non-muscular viscoelastic tissue and new bone has formed some distance from the actual retrodiscal tissue attachment in the fossa (Camilo Yamin, 1997). Microscopic examination of TMJ sections has revealed direct connective tissue attachments of the retrodiscal tissue intothe unique fibro-cartilaginous layer of the condylar head. During orthopaedic mandibular advancement, there is an influx of nutrients and other biodynamic factors into the region through the engorged 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. The result is a metabolic pump-like action of the retrodiscal tissues. Nitzan demonstrated low subatmospheric intra-articular pressures within the TMJ in the open position. The low intra-articular pressure is significant in altering the joint fluid dynamics or flow sof synovial fluid demonstrates low subatmospheric intra-articular pressures within the TMJ in the open position. The low intra-articular pressures were significant in altering the joint fluid dynamics or flow of synovial fluid. Growth relativity theory suggests that bone architecture is induced by the neuromuscular and the contagious non-muscular viscoelastic tissues anchored to the glenoid fossa and altered dynamics of the fluids enveloping bone (John De Vincenzo, 1991).

Glenoid Fossa Remodelling Theory

Woodside (1987) experimented on Macaca fascicularis monkey to demonstrate histologic changes associated with progressive continuous mandibular advancement in juvenile and adolescent monkeys. He found minimum remodeling of condylar cartilage as well as thin pre-chondroblastic and chondroblastic zones at 6 week and 12 week interval. There was no evidence of matrix calcification or remodeling of the osseous trabeculae. The condylar cartilage of the 12-week adolescent showed cell free areas in the superior and anterior regions of the chondroblastic zone. Whereas, there was bone deposition along the posterior border of post glenoid spine and bone resorption along the anterior border. There was dramatic remodeling response of glenoid fossa particularly post glenoid spine. Also, posterior part of articular disk also appeared to proliferate to fill the space created by condylar displacement and contained fibrous tissue and enlarged active fibroblast. This fibrous tissue appears to stabilize anterior condylar displacement. However, it is still possible that such fibrous tissue may resorb after the stimulus is removed and the mandible may partially return toward its original position[15]

REVIEW OF LITERATURE-

De Vincenzo *et al*. (1991) found an increase in mandibular length for 2 years following treatment with Twin block functional appliance therapy which diminished after 3 years, however, no significant difference was found after 4 years (Christine, 2000). Lund *et al*. (1998) in his prospective controlled study investigated skeletal and dental changes produced by Twin block functional appliance therapy findings includes-

Skeletal change

- A mean forward growth/repositioning of the mandible of 2.4 mm (Ar-Pog)
- Increase in the angle SNB.
- No significant maxillary restraint could be demonstrated.
- There was an increase in lower anterior facial height.

Dental change

- The mean overjet reduction of 7.5 mm with 10.8 degree retroclination of upper incisor and 7.9 degree proclination of lower incisors.
- Buccal segment correction by distal movement of upper molars and lower molar movement in anterior and superior direction (Kanoknart, 2000).

Mills *et al* (2000) investigated post-treatment changes following Twin block therapy and concluded as a positive increase in mandibular size can be achieved till 3 years post-treatment, also, there is more uprighting of lower incisors and proclination of upper incisors following treatment. The ramal height increase after treatment is less as compared to the control group (Jean Y.Chen, 2002). Chintakanone *et al*. (2000) assessed condylar as well as articular eminence position following Twin block treatment using magnetic resonance imaging (MRI) and found no evidence of glenoid fossa remodeling in Twin block group as compared to the control group. Also, the position of condyle at the start of treatment was at the articular eminence but 6 months after the treatment there was reseating of the condyle in the glenoid fossa. More anterior position of the condyle in the glenoid fossa was found in the Twin block group. Regarding disk position, author concluded that Twin block appliance has little effect on disk position (Kevin O'Brien, 2003). Chen (2002) reviewed effect of functional appliance on mandibular growth found the need to re-evaluate the use of functional appliance therapy for mandibular growth as studies differ in treatment timing, patient's compliance and cephalometric reference points (Antana Sidlauskas, 2005). Kevin O'brian (2003) evaluated the effectiveness of early treatment with Twin block appliance and concluded as early treatment with functional appliance does not, on an average change the class II skeletal pattern of a child to a clinically significant level (Ashok Kumar Jena, 2010).

Antanas Sidlauskas (2005) studied skeletal and dentoalveolar effects of Twin block in 34 growing Class II div 1 malocclusion patient's and concluded the increase in mandibular length as demonstrated cephalometrically by Ar-Pog, headgear effect on maxilla, and proclination of lower incisors (Antonarakis, 2007).

Ashok Kumar Jena (2005) evaluated the orthodontic and orthopaedic effect of twin block as being an effective appliance to accelerate the growth of mandible whereas Twin block has a minimal restraining effect on the maxilla and maxillary molars. Twin block results in significant forward movement of lower molars which helps to correct molar relationship. Twin block causes significant proclination of lower incisors (Elvira Marsico, 2011). Antonarakis (2007) observed that Twin block have effects on both maxilla and mandible. On maxilla, it has growth restraining effect whereas mandibular skeletal changes are due to stimulation of condylar growth as well as a certain amount of fossa advancement (Sharma Skeletal, 2002). Elvira Marsico (2011) in her systematic review concluded that Twin block therapy showed a statistically significant increase in mandibular length but not clinically significant, which supports recent research that 2-phase treatment has no advantages over 1-phase treatment. But early treatment can be advantageous to prevent trauma, intercept development of dysfunction, and to provide psychosocial effects (Santhana, 2013).

Sharma *et al*. (2012) studied skeletal and dentoalveolar changes following Twin block treatment and concluded headgear effect on the maxilla and significant mandibular sagittal advancement. Maxillo-mandibular skeletal relationship improvement is due to both skeletal as well as dental changes (Ehsani, 2014). Santhana *et al*. (2013) cephalometrically evaluated treatment results of Twin block and found a minimum restraining effect on maxilla and correction of anteroposterior discrepancy mainly due to efficient mandibular repositioning (Ersin Yildirim, 2014). Ehsani *et al*. (2014) systematically reviewed skeletal, dental and soft tissue changes following Twin block treatment. Results of which includes proclination of lower incisor, retroclination of upper incisor, distal movement of upper molar and mesial movement of the lower molar, increase in mandibular length, forward movement of maxilla Clinically significant restraint of maxillary growth not found. Changes in lower facial height and occlusal inclined plane varied, suggesting the vertical dimensions can be manipulated. No long term changes are available (Kortesi

Treatment, 2014). Ersin Yildirim (2014) evaluated through CBCT condylar changes in a patient treated with twin block appliance and observed an increase in condylar volume, mandibular length, and intercondylar distance by stimulating the growth of condyle (Susi Caldwell, 1999). Koretsi (2014) systematically reviewed treatment effects of removable functional appliances in patients with skeletal Class II malocclusion and reported minimum skeletal effect contributing to the correction of malocclusion which is clinically insignificant. But among various removable functional appliances, Twin block presents maximum skeletal change (Santhana, 2013).

Predicting outcome of Twin block appliance using pre-treatment variables

Caldwell *et al*. (1999) in his prospective study investigated the relationship between various measured pre-treatment parameters and reduction in overjet achieved following Twin block treatment found the most strong correlation between overbite and SNB and percentage reduction of overjet. Using these parameters author constructed a predictive equation for the expected percentage reduction of overjet within 6 months as: Liang, 2014.

Percentage reduction in over jet within 6 months =132+4.9X1-1.4X2

Where, X1=overbite and X2=SNB angle.

Effect of Twin block appliance on pulmonary functions

Santhana *et al*. (2013) cephalometrically evaluated changes in the airway dimensions following Twin block treatment and observed a significant increase in upper and lower pharyngeal width and area of bony nasopharynx (Pankaj Pupaneja, 2015). Liang li *et al*. (2014) conducted a CBCT study to evaluate post Twin block changes in upper airway dimensions and found significant enlargement of oropharynx and hypopharynx region, anterior movement of hyoid bone as well as the elliptical shape of oropharynx following Twin block treatment (Chang Zeng, 2013). Pupneja *et al*. (2015) evaluated the effect of Twin block appliance on pulmonary function tests and found a temporary change in lower respiratory tract functions (Andressa, 2014).

CHEN ZANG and PETER NGAN (2013) studied effect of Twin block in Obstructive Sleep Apnea children diagnosed with mandibular retrognathia. The sample was selected on the basis of CVMI Stage 2 and 3 and AHI (apnea–hypopnea index) greater than one per hour. A customized Twin block was given to every patient and was instructed to wear 24 hours for an average of 10.8 months found significant forward movement of mandible after Twin block therapy. AHI was significantly dropped in all the patients by 75.9% after Twin block treatment. Therefore, Twin block can be used efficiently in the treatment of Obstructive Sleep Apnea as a mandibular advancement device (MAD). However long term stability following Twin block treatment need to be evaluated (Aslı Baysal, 2011). Andressa *et al*. (2013) evaluated the effectiveness of Twin block in Obstructive Sleep Apnea patients and compared with results obtained with placebo appliance in accordance with Apnea–Hypopnea Index (AHI), Apnea index per hour of sleep, mean oxyhaemoglobin saturation and percentage of rapid eye movement sleep using prospective longitudinal crossover study design. Found a significant reduction in AHI from 16.3 to 11.7 in the Twin block group. Percentage of REM sleep was also improved in the Twin block group (Chaudhary *et al*., 2016).

Soft tissue changes following twin block therapy: Rapid changes occur in the craniofacial musculature in response to the altered muscle function, as a result of which a significant changes in facial appearance are seen within 2 or 3 weeks of starting treatment with Twin block. The rapid improvement in muscle balance is very consistent and is observed on photographs as a relaxed posture within minutes, hours or days of starting the treatment.

Twin block appliance positions the mandible downward and forward, increasing the intermaxillary space. As a result, it is difficult to form anterior lip seal by contact between tongue and the lower lip and patient adopts a natural seal without instruction. As the appliance is worn full time, rapid soft tissue adaptation occurs to assist primary functions of mastication and swallowing. The patient adopts the lip seal when overjet is eliminated in the most natural way possible by eating and drinking with the appliance in the mouth. This encourages a good lip seal as a functional necessity to prevent food and liquid from escaping from the mouth. Therefore good lip seal is obtained with Twin block, without the need for lip exercises.

Singh and Clark (2003), using finite-element scaling analysis, found a reduction in the prominence of lower lip sulcus following Twin block therapy (Flores mill, 2006). Baysal *et al* (2011) compared soft tissue changes following Twin block and Herbst appliance therapy found greater improvement in mandibular soft tissue following twin block therapy. Twin block results in greater advancement of soft tissue pogonion and lower lip. Chaudhary *et al*. (2015) retrospectively evaluated one-year post-treatment soft tissue changes in Twin block and Forsus FRD with 10 samples in each group with the mean age of 12.5+/-1.5yrs and observed statistically significant soft tissue changes in both Twin block and Forsus FRD. Twin block showed statistically significant changes in the soft tissue including lower anterior facial height, soft tissue profile angle, Holdaway angle, nasolabial angle, and mentolabial sulcus angle. The changes in the middle third of face following twin block treatment were statistically significant but clinically insignificant due to the small magnitude of changes and association with normal growth.

Flores-Mil *et al*. (2015) in systematic review assessed the soft tissue changes following Twin block therapy in Class II div 1 malocclusion patient concluded statistically significant changes in soft tissue profile but the magnitude of this changes may not be perceived clinically. There were no changes found in the anteroposterior position of the lower lip and soft tissue menton.

Conclusion

As a new century approaches, the integration of orthodontic and orthopedic techniques offers a new initiative in restoring facial balance for patients who present skeletal growth discrepancies. However, most of the studies explaining mechanism of action are carried out on animals and therefore, extrapolation of their results to human is questionable to cesrtain extent.

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