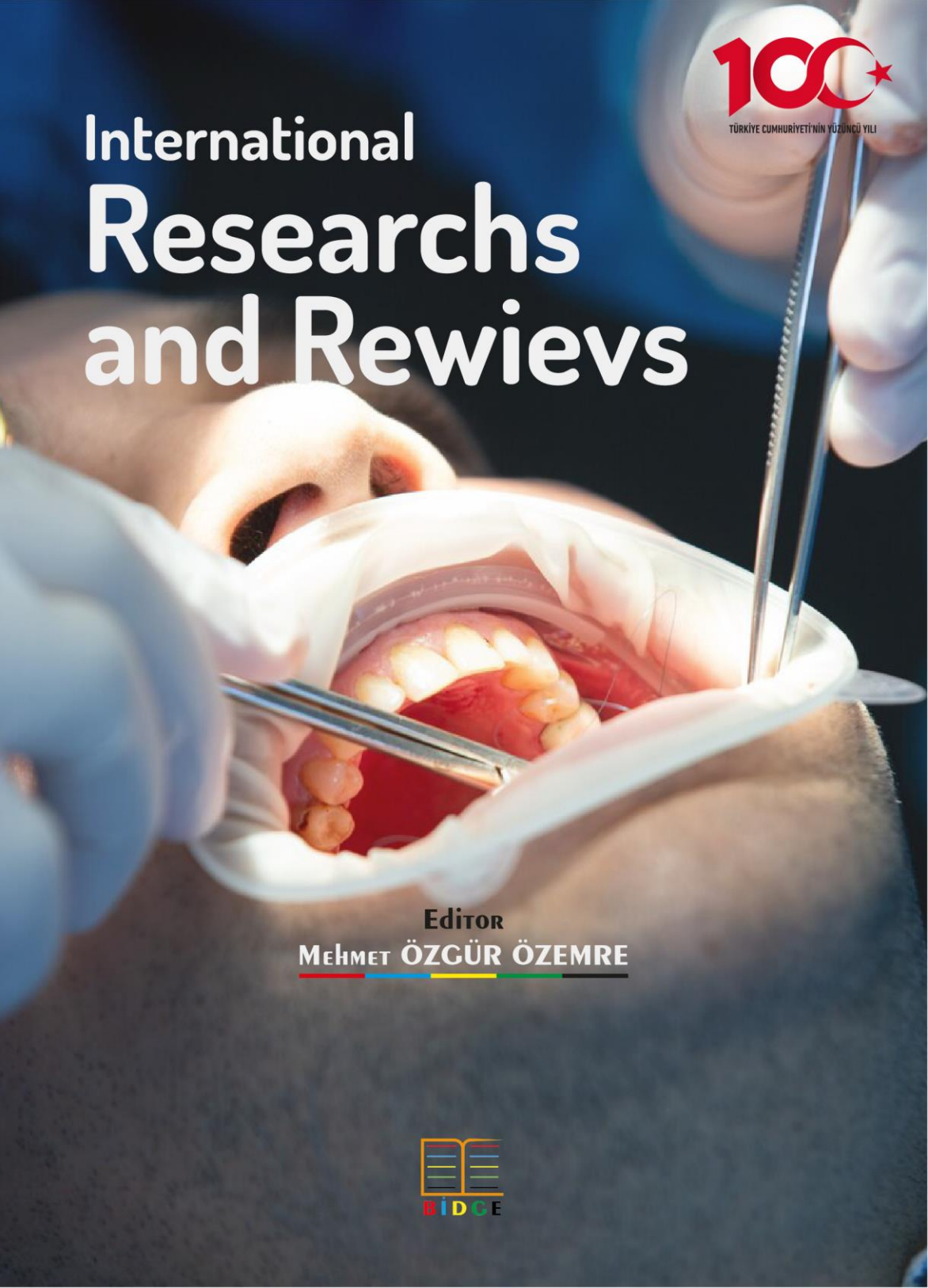

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İÇİNDEKİLER

BÖLÜM I

Non-Surgical Treatment Methods in Temporomandibular Joint Disorders

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Introduction

Temporomandibular disorders (TMD) is a general term defined as clinical problems involving disorders of the temporomandibular joint, masticatory muscles and associated structures, or both. They may present as pain, functional or physiologic impairment.

Although TMD is common, it is 4-6 times more common in women and its incidence increases with age (Benlidayı & Sarpel, 2015).

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Common symptoms include jaw pain or dysfunction, ear pain, headache and facial pain. Diagnosis is usually based on a detailed history and physical examination.

Treatment of temporomandibular disorders includes;

*soft diet,

*behavioral modification,

*medications (NSAIDs, muscle relaxants, antidepressants),

*interocclusal splints, injections (steroids, botulinum toxin),

*physical therapy

*surgical approaches (arthrocentesis, arthroscopy, open joint surgery). Treatment methods are determined after evaluating the degree of the disorder and the structure in which it is located. Treatment methods can be applied alone or in combination.

The etiologies of TMDs are complex and multifactorial and may include occlusal status, trauma, emotional stress and parafunctional activities (Okeson, 2013).

Temporomandibular Joint

The temporomandibular joint (TMJ) is a diarthrodial joint located just anterior to the external auditory canal, between the mandibular fossa under the temporal bone and the mandibular condyle. In a normal TMJ, there is an articular disc consisting of biconcave dense fibrous tissue that rests on the apex of the condyle in the closed mouth position. It does not contain blood vessels and nerve fibers. The disc can be divided into 3 parts according to its thickness in the sagittal plane (Odabaş, 2008).

1. Anterior zone (pars meniscüs): It is the anterior thin end of the disc and adheres to the fibers of the superior lateral pterygoid muscle and capsule.
2. Central zone (intermediate zon, pars grasilis): The thinnest part

3. Posterior zone (pars posterior): It is the thickest part and adheres to the retrodiscal area (bilaminar zone), which consists of dense neural and vascular structures. Synovial fluid provides the metabolic requirements of the nonvascular articular joint surfaces and lubrication of the articular surfaces during function.

TMJ Ligaments

TMJ consists of three functional ligaments.

1. Collateral (discal) ligaments: SRL: Superior retrodiscal ligament IRL: Inferior retrodiscal ligament
2. Capsular Ligaments
3. Temporomandibular Ligaments

TMJ Muscules

The 5 main muscles that contribute to TMJ movements;

1. Temporalis: Its function is to elevate the mandible; its anterior fibers pull the chin up and its posterior fibers pull it back.
2. Masseter: Primarily elevates the mandible. Its superficial fibers contribute to protrusion, while its deep fibers stabilize the condyle against the articular eminence.
3. Medial pterygoid: When the fibers contract, the mandible elevates and the teeth come into contact. It also allows the mandible to move forward.
4. Lateral pterygoid: It consists of two parts. Unilateral contraction of the inferior lateral pterygoid results in lateral movement of the mandible in the opposite direction. The superior lateral pterygoid muscle pulls the disk and condyle medially.
5. Digastric: Pulling the mandible down and back.

TMJ Examination

1. History of the patient: Information should be obtained about the patient's main complaint, the time of appearance of symptoms and their characteristics. Information should also be obtained about the location, character and initiating factors of the pain. The patient's history, treatments and psychological status should also be evaluated.
2. Physical examination: Posture should be evaluated and the patient's mandibular movements should be examined. The temporomandibular joint has rotation (rotation) and translation (sliding) movements. Rotation occurs between the articular disk and the mandibular condyle (inferior synovial cavity). Translation is between the disk-chondyle complex and the temporal bone (superior synovial cavity). Normal mandibular opening is 35-50 mm. Of this movement, 25 mm is provided by rotation and 15 mm by translation. The resting position of the temporomandibular joint is with the mouth slightly distanced, lips joined, teeth not in contact with each other and the first half of the tongue on the hard palate.
3. Joint examination: The joint area should be palpated anterior to the tragus, over the condyle heads and from the external auditory canal.
4. Auscultation: With the help of a stethoscope placed on the joint, it should be checked whether there is a clicking sound, crepitation and whether it is unilateral or bilateral during opening and closing.
5. Muscle examination: It is important to identify sensitive areas for diagnosis.
6. Masseter muscle: painful areas are determined by palpating the anterior component with the thumb and index finger, pressing the adhesion site on the outer surface of the cheeks and the starting point of the muscle on both sides.

7. Lateral pterygoid muscle: Painful areas are determined by inserting the index or little finger between the ascending ramus and tuber maxilla in the cranial direction.
8. Temporal muscle: Fingertips are used to identify painful areas on the head. The patient should open and close his/her mouth during this examination.
9. Sternocleidomastoid muscle (SCM); it starts from the mastoid process and extends to the sternum and clavicle. It is palpated by turning the head in the opposite direction, starting from the front of the earlobe to the end of the neck. The trapezius muscle starts from the occipital region and extends to the scapula. Palpation is performed from both sides starting under the occipital bone.
10. Intraoral and dental examination: Examination of the occlusion, the difference between centric relationship and centric occlusion, signs of abrade and molars on the occlusal surfaces of the teeth, presence of loose teeth, caries, periodontitis and other dental infections, presence of third molars, signs of parafunction (e.g., cheek biting, tongue biting and sucking, teeth grinding), mouth opening.
11. Ear, nose and throat examination: Foreign object in the ear, infection, condition of the pharynx and tonsils should be checked.
12. Radiologic examination: Open and closed joint radiographs and tomographs can be used for the condition of the bony structures, and MRI can be used for the condition of the soft tissues and articular disc (Suca & Akçaboy, 1986).

Treatment Methods

Treatment should aim to correct etiological and pathogenic factors, relieve disease symptoms, restore joint mobility and postural recovery (Yener & Aynalı, 2012). Patients treated in this way mostly achieve improvement of their temporomandibular disorders with the

application of symptomatic treatments. More conservative treatment options should be considered before more invasive and advanced surgical techniques are applied. These; It includes conservative methods such as patient education, soft diet, exercises that the patient can perform himself, physical therapy, occlusal splints and medical treatment for the patient's symptoms.

Patient Education

Excessive and abnormal mechanical loads on the temporomandibular joint can cause stress on the joint and disc and degeneration of the structures. Movements such as clenching or grinding teeth, unilateral chewing, continuous talking, abnormal movement of the jaws, forcing the mouth to open excessively cause disorders in the temporomandibular joint (Khawaja & et al., 2015; Atsü et al., 2019).

Medical Treatment

Analgesics (non-steroidal anti-inflammatories and narcotics), corticosteroids, antidepressants and muscle relaxants are used to relieve pain and inflammation in TMD. In some cases, these medications can be used alone or in combination with other treatment methods (Fletcher MC, 2012). When using these medications, appropriate dosage adjustments should be made against possible side effects. Analgesics, corticosteroids and anxiolytics are useful in the treatment of acute TMJ pain, while anti-inflammatory agents and antidepressants are useful in the relief of chronic pain. Muscle relaxants, NSAIDs and local anesthetics are effective in reducing both acute and chronic pain. Most TMJ pain is associated with inflammation. NSAIDs suppress inflammation by inhibiting cyclooxygenase formation and stopping the synthesis of prostoglandins from arachidonic acid. Glucocorticoids prevent the release of arachidonic acid, an important component of the inflammatory pathway. NSAIDs usually reduce tenderness to palpation of the TMJ within 1 week and help to improve mastication and range of motion-related functions. NSAIDs have been reported to reduce pro-inflammatory proteins called cytokines such as IL-6

and TNF, most of which are products of inflammation in joints. Caution should be exercised in their use with regard to side effects (Fletcher MC, 2012; Mejersjö & Wenneberg, 2008; Okeson, 2013).

Analgesics are used as supportive treatment and opioid and nonopioid preparations can be used depending on the severity of the pain. Non-addictive analgesics may be used when the pain is mild and narcotic analgesics may be used when the pain is moderate to severe. Opioids can also be added as an additional regimen to anti-inflammatory drugs. Nonopiodic analgesics should be used for limited periods of time due to their high addictive potential. Antidepressants including monoamine oxidase inhibitors, tricyclic antidepressants and selective serotonin reuptake inhibitors can be used in patients with intense pain and chronic temporomandibular disorders. These are prescribed for chronic pain, sleep disorders and obsessive-compulsive disorders. The tricyclic antidepressants amiptyline and imipromine are often used and are prescribed for nocturnal bruxism and sleep disorders. The most prominent side effects are related to anticholinergic activity causing sedation, constipation, dry mouth and urinary retention. Selective serotonin reuptake inhibitors (SSRIs) are a new generation of antidepressants and should be prescribed with caution. Although rare, cases of SSRI-induced bruxism have been reported (Gerber & Lynd, 1998; YURTTUTAN & ÜÇOK, 2021).

Occlusal Splint Treatment

It is a noninvasive, easily accessible and effective treatment method with a high success rate in TMD. The main purpose of splints in TMD treatment is to create a functional and stable joint position. They are usually made of hard acrylic that fit on the occlusal surface of the teeth and are in occlusion with the teeth in the opposite arch. The aim is to reduce muscle activity, make changes on muscles and occlusion, change the condyle position and create a placebo effect in patients. It is used for teeth clenching, grinding, internal joint irregularities, and relaxation of hypertonic muscles. The advantages of splints include passivating the facial muscles, decompression of

intra-capsular tissues, providing a balanced occlusal plane, repositioning the jaw, stabilization of the disc, prevention of tooth wear, restoring the vertical dimension, and avoiding parafunctional habits. Ensuring a correct occlusal relationship after splint treatment can help prevent the recurrence of symptoms (Milaro M., 2004; Okeson JP, 2008; Dalkız & Beydemir, 2003).

Types of splits

1-Stabilization splint (muscle relaxing splint)

2-Anterior reposition splint

3-Front bite plate

4-Back bite plate

5-Pivoting splint

6-Resilient split

Stabilization splint: This is one of the most commonly used, easily accessible treatments. These splints are used to eliminate the discrepancy in occlusal position and joint position. Stabilization splints are appliances created with canine or anterior guidance with the help of a special ramp in eccentric movements where the patient contacts all teeth equally in the centric occlusion. In this way, it is aimed to distribute the occlusal loads evenly to all teeth. Occlusal stabilization splints can be modified in different situations and the types that do not cover all teeth may cause elongation of other teeth and change the normal occlusion. Stabilization splints are used in patients with bursitis with muscle hyperactivity, in patients with local muscle tenderness and chronic myalgia, in patients with retrodiscitis as a result of trauma, to remove the force on the damaged tissue, to reduce muscle hyperactivity and joint loads in disc displacements. It is preferred because the upper jaw is more stable, covers more tissue, is more retantive and less fractures occur. It is mostly recommended to use it at night when parafunctional activities are more common, but if it is noticed that parafunctional movements are also performed during the day, patients should be

informed about using it during these periods. After a successful splint treatment, the patient is gradually released. The contact of the plate should be bilateral and canine-protected occlusion should be ensured. Different opinions have been reported regarding the duration of use of the aligners, with studies suggesting that they should only be removed during meals or that they should only be used in the evening (Okeson, 1998). They are used for a minimum of three weeks and a maximum of three months, and most complaints improve after 3 weeks. In patients with an initially transient condition, increased salivation and speech changes disappear as the tongue adapts to the thickness of the appliance. Kahramanoğlu reported that in patients diagnosed with unilateral reduced/unreduced disc displacement using MRI and treated with a stabilization splint, stabilization splint treatment was beneficial in reducing pain symptoms by increasing the amount of mandibular movement in patients with reduced/unreduced disc displacement in the temporomandibular joint (Karamanoğlu, 2020).

Anterior reposition splint: These are appliances applied to reposition the mandible anteriorly to reduce the load on the temporomandibular joint. These appliances are applied to the upper jaw and have a ramp that provides contact with the anterior teeth in the lower jaw. By positioning the mandible anteriorly, it is aimed to create a better condyle-disc relationship in the fossa to ensure adaptation and repair (Okeson JP, 2008). It provides a temporary effect on the condyle and disc and helps the adaptation of retrodiscal tissues. It is used in joint sounds, intermittent or chronic locking and disc displacements. In cases where the disc is dislocated anteriorly, it is effective in reducing joint pain, noise and associated muscle pain. It is contraindicated in the treatment of disc displacement without reduction. Due to its irreversible effects on the occlusion, it is not recommended for prolonged use and is usually discontinued after 6-12 weeks of use. Full arch and rigid acrylic appliances should be made accordingly by setting the anterior stop in the appropriate position that minimizes the patient's symptoms. The stop should be perpendicular to the long axis of the lower incisors without

increasing the vertical height. The patient should bite the stop several times to ensure that the point considered correct is precise and there should be no contact with the posterior teeth; if there is contact, the splint should be thinned. The patient should bring the mandible forward and be instructed to open and close it gently in this position (Hiyama et al., 2003; Okeson JP, 2008). Symptoms should be re-evaluated and the point at which the sound ceases should be marked. There should be no sound after the appliance is placed in the mouth.

Anterior bite plate: Appliances applied to the maxilla that only contact the mandibular lower incisors. It is an appliance that separates the posterior teeth from each other and eliminates dysfunction by regulating the function of these teeth, and is used to treat myospasm caused by occlusal conditions and dysfunctions caused by unwanted posterior tooth contacts. Long-term use is not recommended as it may cause elongation of the posterior teeth that do not meet (Okeson JP, 2008).

Posterior bite plate: These are appliances placed over the mandibular teeth that reposition the mandible and increase the vertical height. It is a hard splint made of acrylic that covers only the posterior teeth. It is recommended for use in cases with severe loss of vertical dimension or in cases requiring significant changes in the anterior positioning of the mandible (Akarsu & Ciğer, 2007).

Pivoting splint: These are appliances that aim to minimize abnormal force and pressure on articular surfaces and increase joint space. This splint is a hard acrylic appliance that is applied to the maxilla or mandible and covers the entire arch and usually has a contact on the last single tooth. The contact placed at the end should be as far posterior as possible and should form the fulcrum axis (Okeson JP, 2008).

Soft splints: These are applied to the maxillary teeth and are made of thermoplastic material and are also called night plates. They are produced in various thicknesses by the manufacturers and sold as prepared plates. It has advantages such as its adaptability to the model, easy preparation and easy leveling. They are used for

emergency cases in patients with pain and dysfunction. These aligners do not require occlusal adjustment and occlusal changes may occur after a while. The aligners used without occlusal alignment may cause an increase in the symptoms of the patients. It has been reported that a soft splint of sufficient thickness, which is made available to the patient with occlusal adjustment, does not cause occlusal changes. It has been suggested that in patients using soft splints, this splint may increase the tendency to clench teeth and thus provoke parafunctional activities such as bruxism (Wright, 2005).

Physical Treatment

Physical therapy options for TMJ disorders include non-invasive and more conservative treatment methods. The aim of physical therapy applications is to reduce muscle hyperactivity, provide muscle relaxation, relieve muscle pain, reduce spasm and edema and restore normal mandibular function by activating tissue healing. There are methods that patients can apply at home and methods that should be applied by professionals. Methods that can be applied at home include cold and warm therapy, jaw opening exercises, lateral jaw exercises, control of passive jaw movements. Methods to be applied in office conditions include ultrasonography, exercises to increase movement capacity, electrical stimulation therapy (TENS), low level laser theraphy (LLLT), injections into trigger points and acupuncture.

Warm Therapy

Heat therapy is used to reduce muscle spasm and pain. They help to relax the muscles by increasing circulation in the areas where they are applied. Heat therapy has two effects on tissues; it acts directly on both free nerve endings and nerve fibers that transmit pain and increases the pain threshold and thus provides analgesia. However, it also helps to reduce pain by dissolving contractions. Decreased blood flow in tissues can trigger myalgias caused by local muscle pain. It is not recommended in cases such as acute inflammation, trauma, hemorrhage, bleeding disorders, sensory

disorders, pain unresponsiveness and communication disorders, thermoregulation disorders, malignancies, ischemia. Thermotherapy applications are applied as superficial and deep heat. Superficial applications can be applied with the help of a hot moist pack or infrared lamp in muscular disorders. Hot moist pack should be applied for about 15-20 minutes until the skin temperature reaches 42◦C (Melzack, 1965). The infrared lamp is always applied to bare skin with the patient lying in a comfortable position. The dose is adjusted so that the patient feels a sweet warmth, the rays should be perpendicular to the application area. The duration of application is 10-15 min in mild dose in subacute cases and 15-30 min several times a day in chronic cases. It is usually applied once a day. Ultrasound and phonophoresis can be used in deep heat therapy (Fletcher MC, 2012; Okeson, 2013).

Ultrasound

They act by converting mechanical energy into heat energy (Whitw & Pharoah, 2009). They are sound waves with a much higher frequency than the sounds that humans can hear. The frequency of the waves used for treatment is between 0.5-3.5MHz. The most commonly used frequencies are 0.75, 0.87, 1.0, 1.5, 3MHz. US can radiate heat to a depth of up to 5cm without causing overheating of superficial tissue (Xin et al., 2016). The most commonly used is 1.5wat/cm2 (Draper et al., 1995). The duration varies according to the size of the area to be treated (3-10min) Practically, the duration can be found by calculating 1min for each 10cm2 area. However, it should not exceed 10 minutes. Since it can cause hemolysis, necrosis or bleeding in the same area when applied to the same area for a long time, appropriate dose adjustment should be made for the treatment to be effective and high doses should be avoided in the same area for a long time (cavitation effect) (Koneru et al., 2012; Rai et al., 2012). Phonophoresis is based on the application of various substances on the skin and acceleration of penetration by applying ultrasound. Local anesthetics or anti-inflammatories may be used.

Cold Therapy

It is used to reduce muscle spasm, bleeding, inflamation and pain. It exerts its anti-inflammatory effect by reducing metabolism and consequent vasoconstriction and phagocytosis. Analgesic effect; directly by raising the pain threshold and indirectly by reducing muscle spasm and edema and suppressing inflammation. Cold packs can be applied 4-5 times a day for 5-7 minutes. It is thought that repair occurs in the tissues as a result of increased blood flow in the process of warming the tissue after cold application (Aktaş & Yalçın, 2000; Weber & Brown, 2000). Melzoek and Wall reported that cold therapy inhibits the stimulation of Aγ fibers, which are stimulated by fine C fibers and are responsible for the transmission of pain (Gray et al., 1994).

Exercises

They can be applied in cases of increased muscle tone in soft tissues, presence of trigger points, tension, decreased capsular flexibility in the joint and restricted joint mobility. Soft tissues are mobilized with superficial and deep point massage, stretching and myofascial release techniques and joint mobilization is achieved with exercises such as mild compression distraction and shifting in opposite directions. Exercises are applied to maintain and increase the range of motion, maintain normal muscle function and increase muscle strength. Stretching exercises (passive, active-passive, active, post isometric relaxation), rotation coordination exercises, resistance exercises, posture exercises are used as exercise therapy (Topuz, 2006). The Rocabado 6x6 exercise program, which is widely used in the literature about TMJ problems and is the most well-known, consists of 6 exercises and 6 repetitions every day. This program consists of tongue resting position, control of TMJ rotations, rhythmic stabilization techniques, neck posterior tilt, round shoulder and neck stabilization exercises (Mulet et al., 2007; Mulla et al., 2015). Another different exercise approach for TMJ problems was made by Kraus. These exercises aimed to inhibit the overactivity of masticatory muscles (Kraus, 2008).

Tens (Electrical Stimulation Therapy)

It was developed in 1965 by Melzoek and Wall after the description of the gate-control theory. It stimulates nerve fibers in a controlled manner through a pair of electrolytes without damaging the skin. This method, which is applied in the treatment of acute and chronic pain, increases blood flow, relaxes hyperactive muscles and helps to reduce pain by removing toxins in the muscle. Both splinting and TENS treatments are effective in the short term in myofascial pain syndrome due to bruxism. However, the duration of effect of TENS application disappears in a shorter time compared to splint treatment. For this reason, it was thought that it would be more appropriate to apply TENS in combination with other treatment methods due to its analgesic effect (Özcan, 2005).

Acupuncture

Acupuncture is a method based on Chinese medicine for more than 3000 years. Although the exact mechanism of action is not known, it is currently thought to stimulate small myelinated nerve fibers in the muscles, which in turn stimulate the spinal cord, mesencephalon and hypothalamus-pituitary axis. Acupuncture is performed by inserting small stainless steel needles into various parts of the body to reduce pain. The body's own antinociceptive system is used for pain modulation. Studies have shown that it is as effective as stabilization splints in treatment and is effective in reducing chronic pain (Liste at al., 1992; Goddart, 2005).

Injection into Trigger Points

Glucocorticosteroids, tenoxicam, morphine, local anesthesia and sodium hyaluronate intra-articular injections can provide lubrication, anti-inflammatory effect and analgesic effect. Corticosteroids are potent anti-inflammatories that reduce effusion in intra-articular injections and have analgesic effect. Corticosteroids administered into the upper joint cavity cause chondrotoxicity and damage to the articular cartilage when used in high doses for a long time in the treatment of osteoarthritis. Therefore, short-term and low

doses are recommended. Local anesthetics or injection of botulinum toxin into myofascial trigger points have been recommended in the treatment of chronic bruxism (Wernecke et al., 2015).

Low Level Laser Therapy

Among non-surgical methods, low-level laser therapy (LLLT) is an alternative treatment option due to its easy application, short treatment time, analgesic, anti-inflammatory, regenerative effects and few contraindications. It is a low-cost and non-invasive treatment option for TMJ pain, chronic orofacial pain, acute and chronic muscle joint pain. The biological effects of LLLT are basically unknown, but they are thought to affect only pathobiologic processes. Apart from increased vascularization, these effects include stimulated collagen production and fibroblast activity, photochemical effects and increased blood supply through improved microcirculation unrelated to the increased temperature in the irrigated tissue. Some studies have found that low-dose laser therapy is effective, while others have found it to be ineffective (Marini et al., 2010; Xu et al., 2018; Yehia et al., 2022). There is no clear opinion on the type of laser, wavelength, areas of application, frequency and duration of treatment (Eroğlu & Feslihan, 2017).

Prolotherapy

Prolotherapy was first performed by Louis Schultz in 1937 by applying dextrose into the joint (Schultz, 1937). Prolotherapy is a minimally invasive injection of various proliferative solutions into damaged, painful, degenerative areas to initiate the inflammatory process and strengthen the muscles or tendons in the area. It is applied for the next stage in cases where other non-invasive treatment methods do not provide a response. Its advantages are that it is more conservative than invasive treatment methods, does not require patient cooperation, does not affect the patient's quality of life, has a relatively low cost and does not have a long recovery period such as the recovery period after procedures such as surgery (Hakala & Lederman, 2010). The aim of prolotherapy is to increase repair in damaged and painful areas, to increase the production of

new collagen and to obtain a joint consisting of more stable and healthy tissues (İnceöz, Akçalı & Solmaz, 2019). Prolotherapy can be applied in many conditions such as musculoskeletal diseases, trauma, osteoarthritis and joint hypermobility. It is not recommended in cases such as the presence of active infection in the injection area, bleeding disorders, presence of tumors in the relevant area, immune and autoimmune disorders, rheumatoid arthritis. In prolotherapy; irritants (phenol, guaiacol), particulates (pumice flour), osmotic agents (dextrose, glycerin), chemotactic agents (sodium morrhuate, sylnasol), platelet-rich plasma (PRP), growth factors are used, but dextrose solution is most commonly used. Dextrose prolotherapy acts through many mechanisms such as direct effect, osmotic effect, inflammatory growth effect and is an easily available and low cost technique (Solmaz, 2019).

Biofeedback

It is a treatment method that provides information about unrecognized physiological events that belong to the person by generating visual and auditory signals by electronic devices and enables the person to be aware of body functions by using this information and to change these functions voluntarily. It is a painless and relaxing method (Dalkız & Beydemir, 2003; Crider et al., 2005)).

Hypnosis

With hypnosis, changes in the consciousness and memory of the person can be created, as well as hypnotically inducing or eliminating muscle, anesthesia, paresthesia, vasomotor changes. It has been observed that TMD-induced pain decreased, and the frequency, severity and duration of symptoms decreased in patients treated with hypnosis (Simon & Lewis, 2000).

Intraarticular Injection

Injection of local anesthetic agents or corticosteroids into the TMJ can be used to treat capsular inflammation. Injection of hyoluronic acid can also be used to prevent pain due to destruction

of the TMJ. Corticosteroid injection into the TMJ has been practiced for more than 50 years and is not recommended for prolonged use due to the destructive effects of frequent steroid use on the articular cartilage and condyle. A total of 3-4 sessions at 3-month intervals is recommended (Laskin, 2001).

Ozone Therapy

Ozone is an unstable compound consisting of three oxygen atoms. It has strong oxidant properties. Although it has been used for many years, its use in dentistry is based on recent times(Latini et al., 2019). It reacts with blood cells and can positively affect cell energy, oxygen metabolism, immunomodulatory properties, antioxidant defense system and microcirculation in tissues(Kazancioglu et al., 2013). It can also exert analgesic effects by oxidizing compounds with double bonds such as arachidonic acid and prostaglandins, which play an important role in the inflammatory response, and by oxidation of albuminolysis products. Contraindications to ozone therapy include pregnancy, glucose-6-phosphate dehydrogenase deficiency (favism), uncontrolled hyperthyroidism, severe anemia, severe myasthenia, severe cardiovascular diseases, heart failure and active hemorrhagia. Medical grade ozone can be applied locally by methods such as intraarticular, intramuscular, intradiscal, subcutaneous and intracutaneous injection, ozonated water, ozonated oil, oxygen / ozone gas (Korkmaz & Küçükkolbaşı, 2013). The use of ozone therapy in temporomandibular joint disorders is recent and there are limited studies. It is used in TMJ internal irregularities, myofacial pain and degenerative disorders of the TMJ. In the studies, patients were divided into various groups and ozone therapy was compared with routine medical treatments or arthrocentesis methods. Ozone therapy has been applied in various ways such as high frequency transdermal biooxidative ozone, intra-articular ozone, ozonized water, ozone gas and although successful results have been obtained, more clinical studies are needed (Torul et al., 2021).

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BÖLÜM II

Arthrocentesis Application Methods

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Introduction

The temporomandibular joint (TMJ) is the only mobile joint in the cranial skeleton, located in front of the external auditory canal, on the posterior upper side of the masseter region, between the prosessus condilaris of the mandible and the fossa articularis of the temporal bone (Türker &Yücetaş, 2004). The fibrocartilage articular disc (discus articularis) divides the joint space into two compartments. The lower joint space provides rotation movement, while the upper joint space provides sliding movement. The TMJ is a "ginglymoid" joint because it makes hinge movements in one plane, but it is also classified as an "arthrodial" joint because it also makes sliding movements. Therefore, TMJ is a ginglimoarthrodial joint (Miloro & al.,2011) In short, TMJ is a complex structure

consisting of mandibular fossa, condyle, disc, eminence, muscles and ligaments (Fletcher & al.,2012).

Arthrocentesis

Arthrocentesis is a simple lavage of the upper joint cavity, usually by inserting two needles. Lavage of the upper joint cavity reduces pain by removing inflammatory mediators, increases the movement of the mandibular condyle by eliminating intra-capsular adhesions, reduces the negative pressure within the joint, and increases the movement of the anteriorly displaced and mobility restricted disc. It is considered as the first interventional option in patients who do not respond to conservative treatment. The major indication of arthrocentesis is acute and chronic limitation of motion due to non-reduced disc displacement and hypomobility due to restriction of condyle translation in the upper joint space (Frost & al.,1999/Dolwick ,1997). Indications of arthrocentesis include non-reduced anterior disc displacements (closed lock), disc adhesions, osteoarthritis and rheumatoid arthritis patients (Nitzan &Price ,2001/ Trieger & al.,1999).

In a study conducted in Istanbul in 2009 on 120 patients, the treatment results of conservative treatment (splint, heat and exercise) and arthrocentesis were compared. No significant difference was found between the success rates in mouth opening, lateral and protrusive movements, but it was stated that arthrocentesis was more effective in reducing pain (Dıraçoğlu & al.,2009).

Contraindications of arthrocentesis include fibrous and bony ankyloses causing limitation of movement and extracapsular problems causing pain and dysfunction. (4) Common complications of arthrocentesis include transient facial nerve paresthesia and paralysis, leakage of ringer's lactate solution into surrounding tissues, but extradural haematoma and swelling in the periauricular region also have been reported in a few publications (Tozoğlu & al.,2011/ Carrol & al.,2000/ Nitzan, 2006).

History of Arthrocentesis

Such a procedure into the upper joint space was first performed by Murakami in 1987. The technique he used was later termed "hydraulic distension" (Murakami & al.,1987). The reference points for entering the TMJ were obtained from the entry points described for arthroscopy by McCain in his 1988 study on cadavers (McCain, 1988).

The conventional method for arthrocentesis was first described in 1991 by Nitzan, who used the two-needle technique (Nitzan & al.,1991).

In 1998, Laskin performed the procedure using the same posterior entry point used by Nitzan, but placing the anterior needle parallel to the posterior needle (3-4 mm). In his opinion, arthrocentesis did not require access to the anterior recess of the joint and it was easier to insert the needle this way (Laskin,1998).

Single-needle arthrocentesis with a three-way tap was described by Alstergren et al. in 1995 (Alstergren & al.,1995). In 2008, Guarda-Nardini reported the use of a single-port single needle, and in 2009, Rehman and Hall used a two-port Shepard cannula (Guarda & al.,2008/ Rehman & Hall, 2009). Also in 2009, Alkan and Kılıc introduced automatic irrigation arthrocentesis of the TMJ. This technique represents double bore arthrocentesis where one of the needles is connected to the surgical implant motor. This modification resulted in higher hydraulic pressure in the joint and shorter procedure time (Alkan & Kılıç,2009). In 2015, Şentürk and Cambazoğlu classified arthrocentesis methods as single and double puncture, and single puncture methods as type 1 and type 2 (Şentürk & Cambazoğlu,2015).

Following the introduction of arthrocentesis, various tools have been reported to be used to visualise the TMJ. In 1991, Nabeith and Speculand were the first to use ultrasonography (Nabeith & Speculand, 1991). In 2006, Honda and Bjørnland described a technique for drilling the upper temporomandibular joint space using

cone beam computed tomography (CBCT) (Honda & Bjornland, 2006).

TMJ Reference Points

The most commonly used references for entering the temporomandibular joint are specific points associated with the Holmlund-Hellsing line (HH-line). In 1985, Anders holmlund and Gustaf hellsing used 2 different types of arthroscopes (rod lens system and so-called Selfoc system) for arthroscopy of the temporomandibular joint (TMJ) on autopsy material and compared them in terms of diagnostic accuracy. They also defined a guide from the tragus to the lateral canthus, saying that the markings on the skin facilitate arthroscopy (Holmlund & Hellsing,1985).

The HH line or tragus-lateral canthus line is an imaginary line extending from the lateral canthus of the eye to the midtragus of the ear. The usual entry points are positions 10-2 and 20-10. Point 10-2 is 10 mm from the ear tragus and 2 mm below the HH-line and is associated with the posterior part of the glenoid fossa. The 20-10 point is 20 mm from the ear tragus and 10 mm below the HH-line, corresponding to the articular eminence process. These entry points may include certain variations (Holmlund & Hellsing,1985).

Arthrocentesis Techniques

A- Single Entry Techniques

- Type 1

  i- Single Needle technique

  ii- 3-way tap technique

  iii- Hydraulic Distension

- Type 2

  i-Y Shaped Needle Technique

  ii- Catheter technique

B- Double Entry Technique

Single Entry Techniques - Type 1

i.Single Needle Technique

A single needle is used for both injection and aspiration of the fluid. While the classical 2 needle technique can be easily applied in the absence of fibrous adhesions in osteoarthritic joints with or without disc displacement, it is more difficult to apply in the presence of intra-articular adhesions. In these cases, single needle technique can be applied more easily.

In the single-needle technique, fluid is injected under pressure while the patient's mouth is open to widen the joint cavity. After the injection, the patient is asked to close his/her mouth and the fluid is discharged from the same injection needle.

Advantages of single needle technique; (Guarda & al.,2008)

- Positioning a single needle provides a safer and more stable access to the joint space, whereas positioning a second needle may destabilise the first.
- The use of a single and more stable needle reduces the trauma of the intervention, consequently resulting in less postoperative pain.
- Since there is no second needle, it does not cause trauma to the facial nerve, which is usually located in the anterior and medial part of the glenoid fossa where the second needle is located.
- There is no risk of outflow of hyaluronic acid from the second point.

ii. Three Way Tap Technique

The insertion site is 10 mm in front of the tragus and 2 mm below the tragal-cantal line. A 19 gauge needle is inserted into the upper joint cavity. A 3-way tap is connected to this needle and 2 syringes are connected to this tap. Approximately 2-3 mL of saline solution is slowly injected into the upper joint space and then

aspirated. Arthrocentesis is performed by the push-pull method. Equality of inflow and outflow is ensured by using injectors of equal volume syringes (Alstergren & al.,1995).

In a study conducted in Estonia in 2016 on 20 patients, arthrocentesis was performed in one group with 3-way tap technique in addition to botulinum toxin injection. In the arthrocentesis group, pain scores decreased significantly and maximal interinsisal distance increased significantly (Ivask & al.,2016).

iii.Hydraulic Distension (hydraulic stress)

Such a procedure in the upper joint space of the TMJ was first performed in 1987 in Japan on 10 patients in whom conservative treatments were not successful. It was then named "hydraulic distension". This study also constitutes the first steps of arthrocentesis. What is important in this procedure is pressurised injection and mandibular manipulation. In this study in Japan, an increase in the interinsisal distance and relaxation of jaw movements were observed in 7 of 10 patients (Murakami & al.,1987).

In a study conducted on 26 patients in Brazil in 2017, patients were divided into two groups. One group underwent arthrocentesis with hydraulic distension and the other group underwent arthrocentesis with two needles and were compared. No significant difference was found between the two groups (Grossmann & al.,2017).

Single Entry Techniques - Type 2

I-Y Shaped Needle Technique (Shepard cannula)

In 2008, in an article published in the UK, it was mentioned that the insertion of two cannulae was quite difficult and therefore it was recommended to use the Shepard cannula (Normed, Germany), which has a single point of entry into the joint with two entrances and two lumens. This device allows both irrigation and flushing. In this article, it is reported that this technique makes intra-articular flushing much easier and increases the success rate. The article

mentions that this cannula has been used for more than 10 years in more than 100 patients without complications Rehman & Hall, 2009).

In 2017, in an article published in Korea, a y-shaped needle design was used. Two 18 gauge needles were bent in a Y-shape with their slopes facing each other. In this two-needle technique, it is mentioned that it is more efficient because the needles' slopes face each other. This technique allows fluids to enter and exit the upper joint cavity faster, accelerating flushing and shortening the treatment time (Mun & al.,2018).

ii. Catheter technique

Single catheter technique

This technique was described in an article in Chile in 2016. This technique uses a single bore 20 gauge 30 mm intravenous catheter replacing two needles. After the intravenous catheter was accurately inserted into the supradiscal space, 3-5 ml of irrigation solution was injected into the TMJ under pressure until resistance was felt and it was difficult to inject more irrigation solution. The capsule was fully stretched to release the adhesions securing the disc to the supradiscal compartment. The tip of the needle was then retracted approximately 3-4 mm. During irrigation, the outflow of the solution from the catheter hub was controlled and inflow was also performed. Non-viscous drugs can be injected by gently reinserting the needle into the catheter, thus preventing the drug from flowing out of the catheter hub (Skarmeta & al.,2016).

The advantage of the single catheter technique is that lavage of the TMJ can be achieved with minimal patient discomfort and postoperative complications. The technique of arthrocentesis with an intravenous catheter represents an easy, cost-effective and safe single-entry arthrocentesis and has been reported to be less traumatic for the patient. Care should be taken not to retract the inner needle too much, especially in joints with severe osteoarthritis, because the

narrow joint space may cause the catheter to bend or collapse or even puncture (Skarmeta & al.,2016).

Double catheter technique

In 2017, a double catheter technique was described in an article published in India. First, a 16 gauge intravenous catheter was inserted through a marked entry point. After that, ringers lactate (RL) is injected to stretch the joint capsule until resistance is felt. The needle of the catheter was completely withdrawn and the catheter hub was cut with scissors at the junction with the catheter tube, leaving only the catheter tube in place. Then,only the needle of the 22 gauge catheter is inserted into the 16 gauge catheter tube which placed into the joint. Approximately 5 mm of the needle is left outside the catheter tube. Such a position keeps the tip of the needle just beyond the 16-gauge catheter tube inside the joint cavity (Nagori & al.,2018).

RL is injected through a 22 gauge needle acting as the inlet port and the solution flows out through a 16 gauge catheter tube acting as the outlet port. Care should be taken not to dislodge the catheter tube and only the needle should be touched during irrigation. To inject hyaluronic acid or other non-viscous drugs, the 22 gauge needle can be removed and the original 16 gauge needle inserted back into the catheter tube, taking care to maintain the position of the catheter tube. The use of this technique may be limited in severely osteoarthritic joints with reduced joint space that may cause the catheter tube to collapse (Nagori & al.,2018).

In the other technique using a single catheter, when the needle is retracted 3-4 mm for flushing, the needle tip comes to the edge of the catheter and they are at the same level, i.e. the inlet port (needle) cannot go beyond the outlet port (catheter). The disadvantage of this is that if the inner needle is retracted too much, fluid may backflow through the cannula system itself without entering the joint space. This may give the clinician a false sense of joint flushing and thus reduce the amount of lavage of the joint. In this technique, the needle of the 22-gauge catheter easily passes

beyond the 16-gauge catheter tube, reducing the possibilit of fluid circulating within the intracatheter. The difference between the length of the catheter tube and the length of the 22-gauge needle is 7 mm.

During arthrocentesis, the needle was kept 5 mm outside the catheter tube so that the needle tip was 2 mm beyond the catheter tube. Furthermore, in the single cannula technique, the space between the catheter tube and the needle is too narrow for the irrigation fluid to flow out of the joint. An attempt was made to overcome this problem by using parts of 2 intravenous catheters of different thickness. The outer port consists of a 16 gauge catheter tube and the inner port consists of a 22 gauge catheter needle. However, it has been mentioned that lavaging is slower than with double-puncture arthrocentesis.

B. Double Entry Technique

A second needle is inserted into the articular eminence area . One needle acts as the entrance and the other as the exit. In most studies, the double-needle arthrocentesis technique has been reported to be effective with or without the use of additional drugs.

In the article published in Kayseri between 2003 and 2011, the motorized arthrocentesis teqnique was described. A 21 gauge needle was inserted into the upper joint compartment from the first point and 5 ml of saline solution was injected to widen the upper joint space. A second needle of the same diameter as the first was inserted through the second point and it was manually verified that the upper joint space was effectively irrigated. The silicone hose of the irrigation pump (KaVo, INTRAsurg 300/300 plus, Biberach, Germany) was connected to the second needle and automatic irrigation was started under high pressure. In all patients, the upper joint space was irrigated with 300 ml of saline for 2 minutes under pressure. This technique should not be used when effective manual irrigation is impossible. No significant difference was found in terms of mouth opening. It was observed that the reduction in VAS values

was greater in patients who underwent motorised arthrocentesis (Alkan & Kılıç, 2009).

Single access technique or double access technique?

In a study conducted at Ankara University Faculty of Dentistry in 2015, arthrocentesis was performed in 40 patients. Patients were divided into two groups as type 2 single-puncture arthrocentesis and double-port arthrocentesis. The first needle was placed in the 10 mm- 2 mm position and the second in the 20 mm and 6 mm position. After the insertion of two 20 gauge needles into the upper joint, the joint was lavaged with 100 ml Ringer's lactate under reduced pressure and no further injection was administered. For single-entry type 2, two 20-gauge needles were soldered in a Y-shape with their openings facing outwards (Şentürk & Tüzüner & Cambazoğlu, 2016).

Maximal mouth opening was measured, VAS and VRS pain scores were recorded and patient satisfaction was evaluated on the first day, first week and first month after surgery. According to the study, there was no significant difference between the two groups in terms of increase in maximal mouth opening and decrease in pain scores. The researchers concluded that both techniques are effective in TMJ arthrocentesis and single access is easier than double puncture (Şentürk & Tüzüner & Cambazoğlu, 2016).

In a study conducted in India in 2020, a total of 59 patients with 60 temporomandibular joints were arthrocentsed with 3 different techniques and compared. Patients were divided into three groups as single-port type 1, type 2 or double-port arthrocentesis group. Total operation time, incidence of needle dislodgement, preauricular swelling and ease of operation were compared (Nagori & al.,2020).

In terms of operation time, single-port type 2 arthrocentesis was shorter. There was no significant difference between single-port type 1 and double-port technique. The highest incidence of needle

dislocation was observed in double-port arthrocentesis. Less intraoperative dislocation was encountered in single-port techniques.

Preauricular swelling (extravasation of fluid) was seen in 7 patients with double-port arthrocentesis, 3 patients with single-port type 1 arthrocentesis and 3 patients with single-port type 2 arthrocentesis. In terms of ease of operation (surgeon 0-10 score), single-port type 2 arthrocentesis was reported to be the easiest, and no significant difference was found between single-port type 1 and double-port technique (Nagori & al.,2020).

Between August 2013 and August 2015, arthrocentesis procedures were performed on 32 joints of 32 patients diagnosed with anterior disc displacement without reduction based on magnetic resonance imaging at Erzurum Atatürk University, Department of Oral and Maxillofacial Surgery. Patients were divided into two groups as single-port type 1 arthrocentesis and double-port arthrocentesis. There was no significant difference between the two groups in terms of maximum mouth opening, pain at rest, pain during mastication, pain at maximum mouth opening, tenderness level and treatment tolerability and the amount of analgesic required. The difference between the procedure times was statistically significant. Double-entry arthrocentesis was reported to be shorter (Bayramoğlu & Tozoğlu,2021).

In a study published in 2021, articles published in the Scopus database between 2016 and 2020 were analysed. In the articles examined in the study, arthrocentesis treatment of a total of 2675 patients and 2740 joints was analysed. The aim of this study was to highlight the advantages and shortcomings of different methods. The systematic overview of single and double puncture techniques of arthrocentesis concludes that there is no evidential superiority of one over the other. It is emphasised that the choice of the method used depends on the surgeon's preference and experience (Gudova & Oras & Ivask,2021).

Arthrocentesis with radiological imaging

Radiological imaging can be used with single and double needle techniques. Ultrasonography (USG) is helpful when locating the upper joint space of the TMJ and for needle placement for arthrocentesis. Cone beam computed tomography (CBCT) and computed tomography (CT) can be used to guide needle insertion. Magnetic resonance imaging (MRI) is mostly used for diagnostic purposes.

In a study conducted at Marmara University Faculty of Dentistry in 2016, 20 patients were divided into 2 groups and one group underwent conventional arthrocentesis and the other group underwent USG-guided arthrocentesis.

There was no significant difference between the number of displacement of the first or second needle and surgical pain scores. According to the study, USG-guided arthrocentesis took significantly longer than the conventional technique. Pain scores and maximal interinsisal patency did not differ significantly preoperatively, immediately after the procedures or at any time thereafter (Sivri & al.,2016).

In a study conducted in Germany in 2018, 20 patients were divided into 2 groups; one group underwent double-lumen single-port arthrocentesis (a Y-shaped needle) and the other group underwent USG-guided double-lumen single-port arthrocentesis (a Y-shaped needle). The ultrasound probe was placed over the temporomandibular joint, perpendicular to the zygomatic arch and parallel to the ramus of the mandible, and tilted until the best visualisation was obtained (Bhargava & al.,2019).

According to the study, USG improved needle manipulation and reduced the number of needle interventions. It also shortened the operation time, but no significant difference was found between the two groups in terms of VAS scores for pain. According to the study, USG-guided arthrocentesis;

- Provides easy needle manipulation.

- Minimises complications.

- Provides easier access to the joint cavity.

- Allows operation with minimum trauma.

In a study conducted in India in 2018, 80 patients with TMJ dysfunction were divided into a control group treated with conventional arthrocentesis and an experimental group treated with ultrasound-guided arthrocentesis.

The VAS score of TMJ pain improved significantly in both groups. In 16 of the 40 patients in the control group, the needle was repositioned for proper outflow of lavage fluid, and it was reported that multiple inlets were needed to obtain a successful lavage with conventional arthrocentesis. In the experimental group, no repositioning was required because the needle placement was perfect. Therefore, there was a greater reduction in pain scores in the first 3 days in arthrocentesis performed with USG (Antony & al.,2018).

Guide Assisted Arthrocentesis

It was thought that a tragus-supported guide for the temporomandibular joint could facilitate needle placement. The guide was created with a headset-like design based on a cone beam computed tomography (CBCT) scan. The first needle was positioned on the posterior slope of the articular tubercle. The second needle was placed 5 mm in front of the first needle and the third needle was placed 2 mm below the second needle. Penetration depths were 28, 38 and 40 mm, respectively. A sterile ultrasound (US) probe was placed on the TMJ and the position of the first needle was double-checked. All needles were correctly positioned on the first attempt. This technique provided safer and more precise placement of needles for arthrocentesis procedures (Göçmen & Bayram & Özkan, 2020).

Agents that can be injected into the joint

Hyaluronic acid (HA)

Hyaluronic acid (HA), also called hyaluronate and hyaluronan, is a glycosaminoglycan. It is produced by chondrocytes and synoviocytes in the joints. In osteoarthritic joints, there is a 35-50% decrease in HA concentration and molecular weight, which increases osteoarthritic changes. It is aimed to replace the low HA ratio and increase endogenous HA production in the joint (Bagga & al.,2006). HA has many injectable forms. It has a low molecular weight and increases proteoglycan synthesis, triggers the proinflammatory cascade and promotes proliferation and differentiation of chondrocytes (Kawasaki & al.,1999).

Platelet rich plasma (PRP)

Platelet-rich plasma (PRP) is obtained by high centrifugation of whole blood. It can be defined as an autologous solution of platelets containing a large number of growth factors at a concentration 3-8 times higher than whole blood. PRP shows a potential healing effect on new bone and cartilage by acting on the proliferation, migration and differentiation of cells, chondrogenic differentiation, matrix production and tissue remodelling (Marx,2004 / Cömert & Güngörmüş &Sümbüllü,2015).

Corticosteroids

Depomedrol and methylprednisolone acetate have found widespread use among glucocorticoid agents. It has been shown in various clinical studies and meta-analyses that corticosteroid injections can be used frequently to provide functional improvement in osteoarthritic joints and to reduce pain in the early period (Bellamy & al.,2006).

In a study conducted in 2016 at Atatürk University Faculty of Dentistry, all patients were divided into 4 groups. One group received only arthrocentesis and was the control group. One group received hyaluronic acid, one group received corticosteroids and the

last group received platelet rich plasma. In the PRP group, PRP injections were administered once a month for an additional 4 sessions following intra-articular anaesthesia. The main outcome variables were pain scores on lateral and posterior palpation of the temporomandibular joint and were evaluated before and 1 year after treatment (Cömert & Güngörmüş,2016).

A statistically greater improvement was observed in the pain scores of lateral and posterior TMJ palpation in the PRP group and posterior TMJ palpation in the HA group. No significant improvement was observed in the KS group. The study showed that PRP provided a more effective improvement.

Conclusion

In general, studies show that single and double entry techniques of arthrocentesis are not clearly superior to each other. The choice of the method used depends on the experience and choice of the surgeon.

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BÖLÜM III

Corticobasal Implants: Review of Literature

Mehmet Alp ERİŞ[1]
Mehmet Emre YURTTUTAN[2]

INTRODUCTION:

Corticobasal implantology is a modern and innovative implantology system that uses the basal cortical part of the jaw bones, which is less prone to resorption and infection, for the stabilisation of dental implants. Corticobasal implantology is also referred to as bi-cortical, basal osseointegrated, basal, cortical, orthopaedic and strategic implantology.

From past to present, corticobasal implants have been used and developed especially by German and French dentists. The first

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one-piece implant was developed by Dr Jean-Marc Julliet in 1972 and entered our lives. The only disadvantage of this system used by Dr Jean-Marc Julliet was the lack of a surgical set (Yeshwante et al., 2016). In the 1980s, French dentist Dr Gerard Scortecci developed an implant system with a suitable surgical set and external and internal connection parts for the prosthetic superstructure and called it the "Disc Implant" (Scortecci, 1999).

By the 1990s, a group of German dentists had developed new implant systems and surgical instruments based on the disc implant system, which led to the development of the modern basal osseointegrated implant, also known as the lateral implant. These implants are designed to provide masticatory load transmission in the basal part as well as the vertical part. These implants are designed to provide load transmission in the basal portion as well as the vertical portion (Yeshwante et al., 2016).

Dr Stefan Ihde started to produce lateral basal implants in 1997. These implants were of limited design and dimensions and consisted of rough surfaces. Soon after, Dr Ihde developed designs with edges instead of round apical plates to prevent rotational movement before integration. In 2002, the unbreakable plate was invented and patented in Europe and the United States. Bending zones were introduced in the vertical implant shaft. In 2005, screwable designs (BCS, GBC) were introduced (Ihde, 2005).

In 1999, vertical parts were first produced with a smooth and polished surface. Since 2003, implants have been produced in one piece with a polished surface that is not prone to inflammation. In addition, in case of sterile loosening on smooth surfaces, reintegration of the implant is possible if intervened in time. The design has been developed to be fracture-resistant, leaving sufficient flexibility for bone growth and functional stimulation (Ihde, 2009a).

CLASSIFICATION:

Corticobasal implants are basically classified into four forms (Figure 1, Figure 2, Figure 3) (Gupta et al., 2017).

- Screw-formed
- Disc shaped
- Plate shaped
- Other forms

These implants, which are classified according to their forms, are divided into separate groups.

1. Screw Formed
   a. Compression Screw Design (KOS Implant)
   b. Bi-Cortical Screw Design (BCS Implant)
   c. Compression screw + Bi-Cortical Screw Design (KOS Plus Implant)
2. Disc Formed
   a. According to the abutment connection
      i. One-piece Implant
      ii. External Threaded Connection
      iii. Internal Threaded Connection
         I. External Hexagon
         II. External Octagon
   b. According to the basal plate design
      i. Basal discs with angled edges
      ii. Basal discs with straight edges (also called S-type implants)
   c. According to the number of discs
      i. Single Disc
      ii. Two Discs
      iii. Three Discs
3. Plate Formed
   a. BOI-BAC Implant
   b. BOI-BAC2 Implant
4. Other Forms
   a. TPG Implant (Tuberopterigoid)
   b. ZSI Implant (Zigoma Screw)

Figure 1: a. KOS b. BCS c. KOS Plus Implant

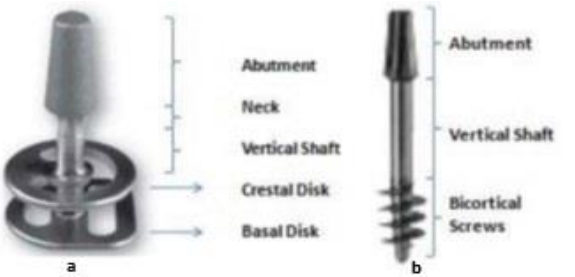

Figure 2: a. Basal Osseointegrated Implant (BOI) b. Bicortal Screw Design (BCS)

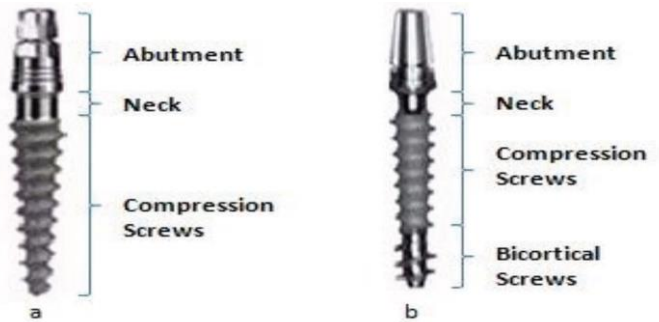

Figure 3: a. Compression Screw Design (KOS) b. Compression Screw and Bicortical Screw Design (KOS Plus)

PARTS OF THE BASAL IMPLANT:

Roughening the surface of implants to provide a modified interface by increasing the surface area has been widely applied. Such rough surfaces can harbour osteoblasts as well as a large number of bacteria. This situation, which ensures osseointegration, causes bacterial colonisation and predisposes to inflammation such as mucositis and periimplantitis (Grishmi & Mitul, 2017).

Areas where stress and deformation occur are potential entry sites for such pathogens. After loading, the implant causes a stress in the crestal region. This provides an entry route and a rough surface that is favourable for such bacteria. While osseointegration occurs in the basal disc region, the stress is limited to the vertical component of the implant as evidenced by finite element analysis studies. This distinction means that roughening of the surface is only required in the basal disc and the vertical component must be smooth. Therefore, the crest crest, the site of entry of bacteria, would be unfavourable for bacterial colonisation (Ihde et al., 2008).

Most of the currently produced BCS and BOI implants have smooth and shiny surfaces. Because shiny surfaces are less prone to inflammation (such as mucositis, perimplantitis) than rough surfaces (Gupta et al., 2017).

KOS and KOS Plus implants are subjected to surface treatments such as sandblasting and acid etching, but in KOS implant designs, the implant neck consists of a shiny and smooth surface. In the KOS Plus implant design, the implant neck and the basal cortical screw portion are formed from a completely shiny surface (Gupta et al., 2017).

COMPARISON

Corticobasal implants differ from conventional implants both in their design and surgical procedures (Ihde, 2009b).

Corticobasal Implants

- It is used in multiple tooth deficiencies, especially in extraction sockets.
- Cortical anchorage of fine screw implants and excellent primary stability along the vertical surfaces of these implants can be achieved.
- Immeat installation within 72 hours
- Wide variety of implants in a wide range of sizes and designs
- Basal bone is denser and mineralised and less prone to bone resorption.
- They have a simpler surgical set.
- A single-session surgical procedure is performed.
- It is a simple procedure that does not require bone augmentation.

Conventional Implants

- It is used in single or multiple tooth deficiencies, in the presence of sufficient bone tissue.
- Formation of a direct interface between implant and bone without intervening soft tissue
- Delayed loading within 3-6 months
- Limited range of implants in size and design
- Crestal alveolar bone is more prone to resorption.
- The need for a large number of hand tools for two-part implant application
- More complex surgical procedures are required and these procedures often require 2-3 sessions over 3-6 months.
- They may require extra and complex surgeries such as bone augmentation.

INDICATIONS

- Multiple missing teeth or conditions requiring multiple tooth extractions
- Failure of 2-stage implant treatment or bone augmentations
- All types of bone atrophies
  - Insufficient bone height
  - Very thin bones (e.g. knife-edge bone form with a buccopalatal thickness of less than 2 mm) (Pathania et al., 2021)

CONTRAINDICATIONS

- A history of severe bruxism, clenching, uncontrolled malocclusion and/or broken teeth, especially when associated with psychological problems
- High-dose IV bisphosphonates used to treat severe osteoporosis or cancer (risk of osteonecrosis of the jaw).
- In the presence of facial and trigeminal neuropathies
- Severe heart disease, recent infarction (risk of infective endocarditis), uncontrolled diabetes, untreated renal failure.
- Ongoing radiotherapy for cancer (risk of osteoradionecrosis of the jaw, especially after radiation of the head and neck region).
- Patients under 15 years of age
- Allergies or hypersensitivity to chemical components of the material used: titanium (Ti6Al4V) alloy [12]
- Some diseases of the oral mucosa
- An unbalanced relationship between the upper and lower teeth and poor oral and dental hygiene
- Infections in neighbouring teeth (pockets, cysts, granulomas, major sinusitis)(Ihde, 2019)

ADVANTAGES

- The prosthesis can be applied within 72 hours after implant surgery, saving considerable time and cost.
- Most of these implants are supported by basal bone, which is much more resistant to resorption, and basal cortical bone has a much more rapid and stable repair capacity.
- It is unique in utilising existing bone in the best possible way to avoid bone augmentations.
- These implants work well in patients with controlled diabetes, smokers and patients with chronic destructive periodontitis.
- In addition to the extraordinary reduction in total treatment time, it helps to save costs substantially by avoiding bone grafts and second-stage surgery.
- Basal implants have a smooth surface, thus preventing peri-implantitis (Rahul et al., 2016).

DISADVANTAGES

- Inadequate aesthetics in single tooth deficiencies
- It requires high anatomical knowledge and surgical experience.
- Excessive need for bone reduction in cases of good bone support
- If the load distribution is not done properly, osteolysis may occur due to overloading (International Implant Foundation, 2022a).

PERIIMPLANT BONE HEALING

Because of their special design, peri-implant healing is also special. The bone remaining after tooth loss and complete resorption of the alveolar crest is called basal bone. This bone structure has ten times less turnover than alveolar bone and is highly susceptible to thermal damage and infection. In atrophic jaws, the main blood supply is from the inner layer of the periosteum, so maintaining

aseptic conditions during surgery, careful handling of the periosteum, abundant saline irrigation during lateral osteotomy and primary stability are of utmost importance in bone healing after placement of the basal implant (Henri, 2008).

While the term "Osseointegration" is used for conventional implants, the term "Osseoadaptation" is used for basal implants, because with continuous functional loads, the bone remodels and eventually adapts to the implant surface. According to the philosophy of basal implantology, the process of osseoadaptation is performed by a "Bone Multicellular Unit" (BMU), which is formed when BOI and BCS implants are subjected to sudden loading, which then leads to bone remodelling under functional stresses and ultimately forms the BMU unit, thus initiating the healing phase and leading to a dense peri-implant bone formation (Figure 4). Basal implants utilise the same principles of peri-implant healing and bone densification, which is why they are also referred to as "orthopaedic implants" (Ihde, 2005).

The healing process includes the following steps respectively (Pathania et al., 2021).

1. Activation Phase
2. Resorption Phase
3. Reverse Phase
4. Progressive Phase
5. Mineralisation Phase
    a. Primary Mineralisation Stage
    b. Secondary Mineralisation Stage
6. Dormant Phase

Activation Phase

In this stage, which lasts for three days, precursor cells/human mesenchymal stem cells are transformed into osteoblasts and osteoclasts.

Resoption Phase

In this phase, osteoclastic activity (occurring at a rate of 40 μm/day) is dominant. The bone shows a soft and porous formation.

Reverse Phase

At this stage, osteoblastic activity occurs in which osteoblasts deposit new bone into the haversian canals at a rate of 1-2 μm per day.

Progressive Phase

Osteoblasts form concentric lamellae in the haversian canals, resulting in a decrease in canal diameter and an increase in bone density. At this stage the diameter of the haversian canal is 40-50 μm. Non-mineralised Matrix Osteoid is newly formed bone and this stage lasts for 3 months.

Mineralisation Phase

It starts ten days after osteoid formation. It consists of two stages.

1. Primary Mineralisation Stage - gives primary hardness to the osteoid and accounts for 60% of all mineralisation.

2. Secondary Mineralisation Stage - gives the final hardness and final morphology of the bone. This phase lasts 6-12 months.

Dormant Phase

Osteocytes that develop from osteoblasts line the haversian canals and fulfil mechanical, metabolic and homeostatic functions. During these phases the implants are under functional load, which leads to continuous stimulation of the BMU throughout the life of the implant, which increases peri-implant bone density (which increases throughout the life of the implants) and adapts to the implant surface, so-called "Osseoadaptation".

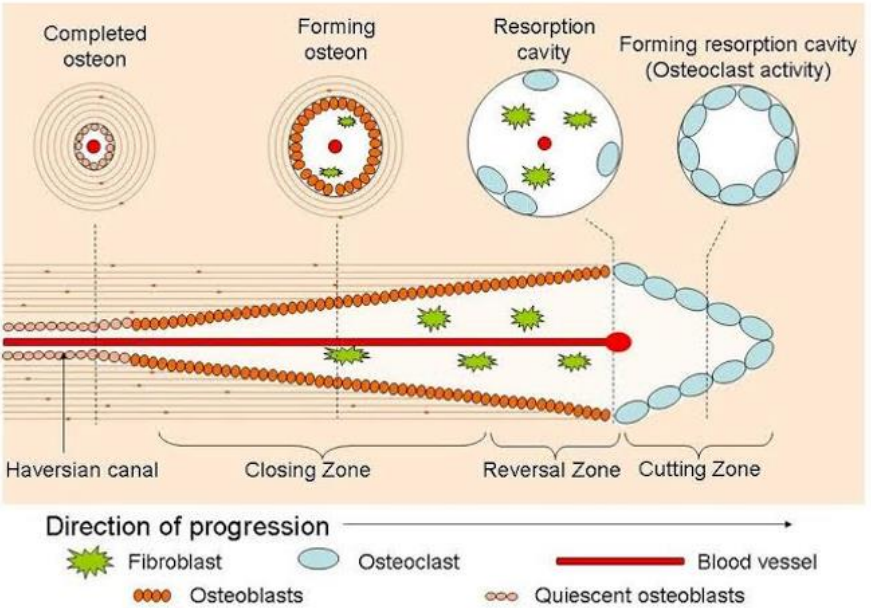

Figure 4: Bone Multicellular Unit (BMU). The resorption zone is composed of osteoclasts, followed by the recharge zone composed of osteoblasts, and the region between the two is called the reversal zone.

Approaches for the Formation of a Permanent Bone-Implant Connection

Since 1990, the concept of "Osseointegration" has been predominantly accepted in dental implantology. Implants are expected to undergo osseointegration during a healing period of 3-6 months by achieving primary stability during surgery. It is assumed that the roughness and design of the implant surface affects bone healing and does not advocate immediate loading.

Prior to this period (from 1956 to the 1990s), the use of implants with polished or machined surfaces was favoured, as implants had to be in close cortical contact to obtain adequate cortical support. In this treatment approach, immediate loading

protocols and one-piece implants were mostly used. In 2022, the International Implant Foundation defined various methods to create a successful implant-bone connection (International Implant Foundation, 2022b).

Osseointegration Approach

Osseointegration is preferred in cases where adequate primary stability for immediate loading cannot be achieved and secondary stability is desired. This method does not require cortical support or anchorage to provide optimum stability, but the greater the cortical contact, the greater the stability. In this method, immediate loading is sometimes possible. (Ex: All on Four Technique)

It should be noted that the term osseointegration does not imply that the bone tissue is somehow attached to the surface of the implant (Figure 5). Due to rough surfaces, many mechanical retention sites are created during osseointegration.

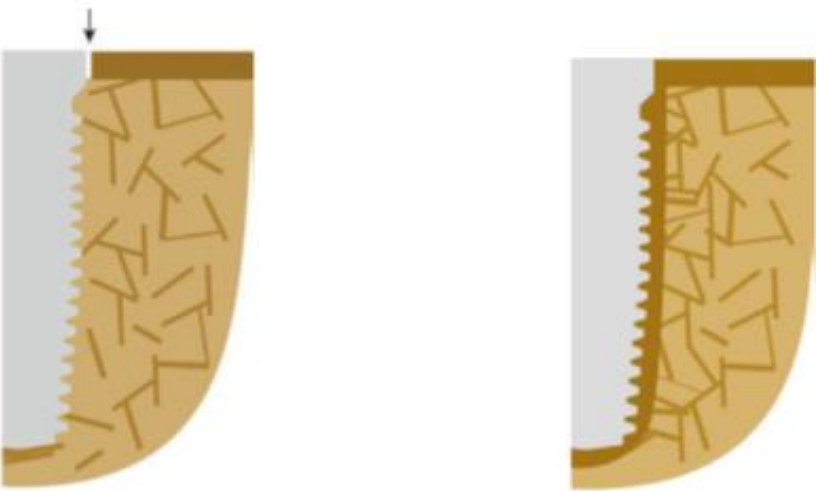

Figure 5: Corticalisation of the implant-bone interface in the osseointegration approach

Osseointegration is actually the corticalisation of bone tissue near the surface of the implant. It has disadvantages such as healing time, high bone-implant surface requirement, periimplantitis development due to rough surface.

Compression of Spongiosis Bone

All conical shaped endosseous implants can be considered as "compression screws". A small diameter conical pointing drill is used to create a slot that allows the implant to be compressed. Then, following implant placement, the spongious bone displaces laterally and apically to form a zone of mineralisation. This process is called "corticalisation of the spongious bone" (Figure 6). As soon as the implant is loaded, more cortical bone is formed in response to the functional load. This approach provides sufficient stability for a functional loading protocol in D2-D3 bones with sufficient mineralisation capacity.

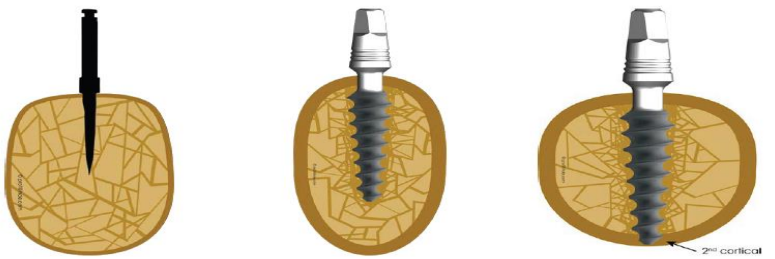

Figure 6: Formation of the mineralisation zone by compression of the spongiose bone

Direct Cortical Interaction

Immediate loading protocols are possible if the implants are placed under pressure in direct contact with the cortical bone (Fig. 7). In this method, there is no need for a minimum amount of bone in the vestibular or lingual/palatal regions of the implant. What is important is that the cortical bone remains intact without showing even a green tree fracture.

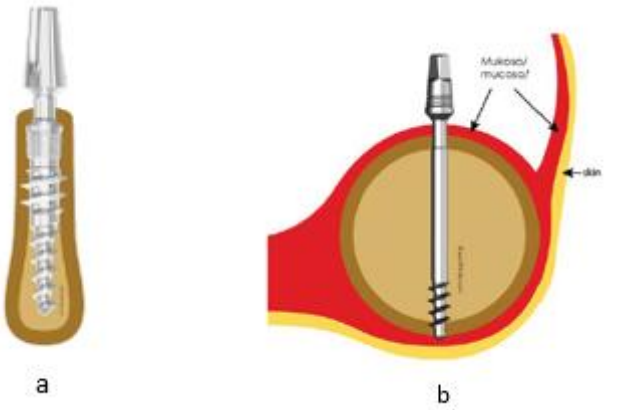

Figure 7: a. Cortical interaction directly from the buccal and lingual bone b. Cortical interaction directly from the apical basal bone

Corticobasal implants are attached by direct cortical bone attachment (Osseofixation). The implants are characterised by their apical grooves, which are attached to the cortical bone with high primary stability. The implant contains a 0.7 mm thick thin guide that allows the implant to safely advance into the second or third cortical layer during insertion. This tip can be removed to obtain more anchorage when penetration is less desirable.

Corticobasal implants have isoelastic properties that depend on nominal diameter, length and design. Due to these properties, they differ significantly in indication and use from conventional implants designed for the old "Osseointegration Method".

Lateral Basal Implants and Blade Implants

Lateral basal implants are driven into thin slots formed in the bone with the help of a hammer (Figure 8). In this approach, the implants gain their primary stability by compression of their plates between the cortical bone. The slot is then filled with immature woven bone. These implants tend to fail if they are not in contact with the cortical bone in the final position.

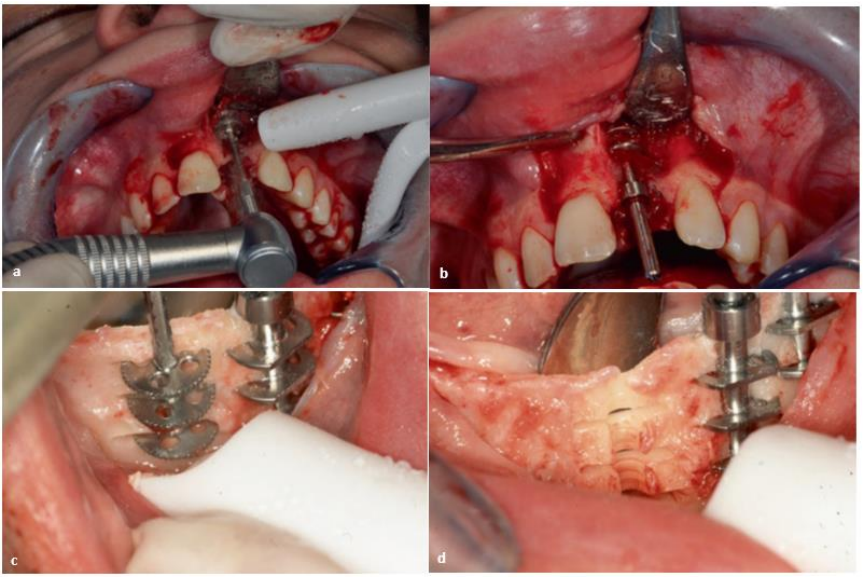

Figure 8: a. Preparation of the lateral basal implant socket in the anterior region of the maxilla b. Application of the lateral basal implant in the anterior region of the maxilla c. Preparation of the lateral basal implant socket in the anterior region of the mandible d. The lateral basal implant socket in the anterior region of the mandible reaches the lingual cortical layer.

16 Surgical Methods Described for the Application of Basal Implants

The International Implant Foundation (Munich, Germany) has published this consensus document on 16 clinically successful anchorage techniques for corticobasal oral implants to define standardised treatment methods. This consensus document only describes proven methods without recommending a specific number of implants per jaw or per segment. However, it is understood that the number of implants used will typically be higher compared to treatment plans in conventional dental implantology (Antonina et al., 2020).

Method 1

Spongious alveolar bone areas are avoided for anchorage. The primary goal of treatment with corticobasal implants is "osseo-fixation", not "osseo-integration". Corticobasal implants are fixed to the cortical bone. After fixation, the implant shafts are bent and parallelised to fit the prosthetic restoration. They are then splinted with a rigid structure consisting mostly of titanium bars. This process is called 'welding' (Figure 9). Welding is preferred as a rigid splint, especially in cases where periodontally healthy patients cannot have permanent prostheses. A temporary prosthesis made of acrylic can be made on these titanium bars.

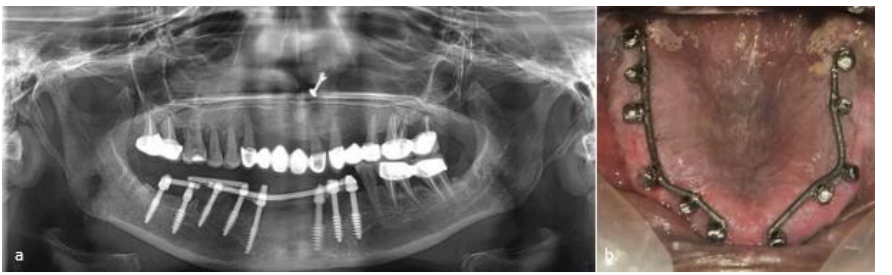

Figure 9: a. Panoramic image of the patient with corticobasal implant b. Intraoral image after welding

Method 2

In the anterior region of the edentulous mandible, implants can be placed between the mental foramen with or without using the caudal cortex of the mandible.

The implants are placed apically towards the tip of the jaw (symphysis) (Fig. 10), which prevents damage to the mental nerve. Typically, two implants are used on each side of the mandible. If the anterior mandibular bone shows insufficient mineralisation, the caudal cortex can be used for anterior anchorage.

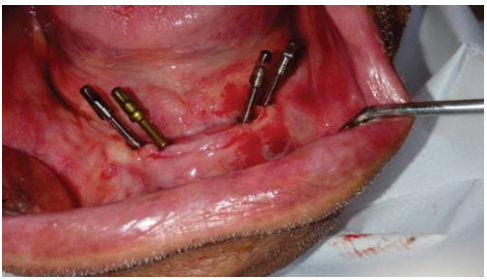

Figure 10: Corticobasal implants applied at an angle in the anterior mandible

Method 3

Anterior anchorage of segmented bridges can be achieved by placing implant(s) in the space between the canine root and the mental foramen. The grooves of the implant can extend from below the canine root to the caudal cortical bone of the mandible and can be fixed to this bone to the extent necessary to achieve stability (Fig. 11).

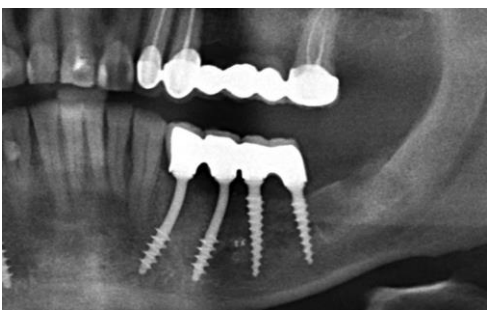

Figure 11: Corticobasal implant extending between the mental foramen and canine root

Method 4

Method 4a

Nerve bypass (Fig. 12)- The corticobasal implant can be positioned endosseously in the distal (proximal) mandible, bypassing the inferior alveolar nerve on the lingual or vestibular

side, providing anchorage through the caudal cortical bone if necessary/possible, but without passing through the cortical bone with the implant apex.

Method 4b

Nerve bypass - The corticobasal implant can be positioned endosseous in the distal (proximal) mandible, bypassing the inferior alveolar nerve on the lingual or vestibular side, with anchorage in the caudal cortical bone if necessary/possible, with cortical penetration of the implant apex.

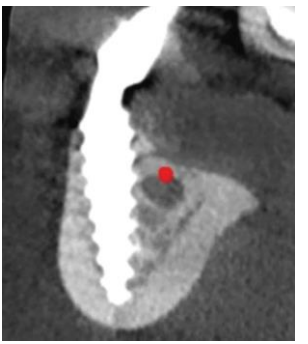

Figure 12: Bypassing the inferior alveolar nerve

Method 5

Method 5a

Cortical anchorage can be provided from the lingual bone distal to the mandible (Figure 13). The implant can be placed by anchoring the load transmitting grooves under the mylohyoid ridge on the lingual bone anchor. The apical end of the implant must be fully fixed to the lingual cortical bone.

The inferior alveolar nerve will pass caudal to the implant body. As a rule, two or more such implants are placed distal to the mental nerve (i.e. in the proximal, horizontal part of the mandible). Typically, the inclination of the heads of these implants (before bending) is towards the anterior implants.

Method 5b

Vestibular cortical anchorage can be provided in the distal mandible. The implant can be placed by providing anchorage in the vestibular cortical bone and crestal to the inferior alveolar nerve.

Method 5c

Vestibular cortical anchorage can be achieved in the distal mandible so that the implant passes under the mandibular nerve. This method is used when the inferior alveolar nerve is positioned crestally and the distal mandible is wide and high enough to allow such a placement.

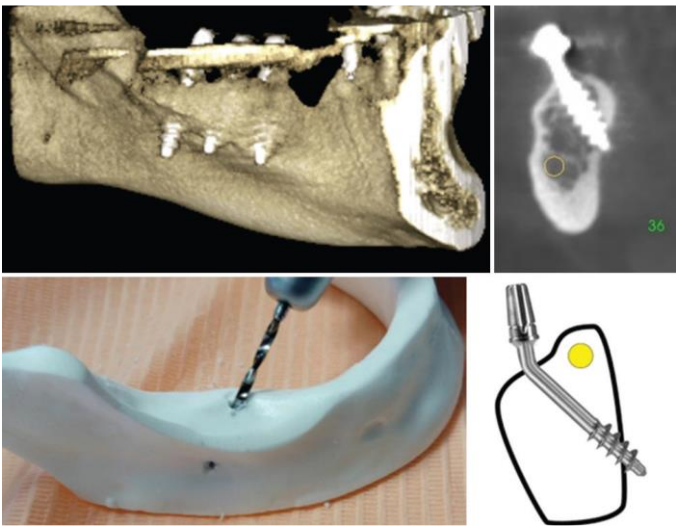

Figure 13: Anchorage from buccal and lingual cortical bone by placing the implants at an angle

Method 6

A corticobasal implant can be placed for palatal/lingual and vestibular support, reaching the cortex without using the second layer of cortical bone in the vertical direction (Fig. 14). The main areas of application are as follows:

- Extraction sockets of mandibular and maxillary premolars
- Lower and upper anteriors
- Tuberosity of the maxilla

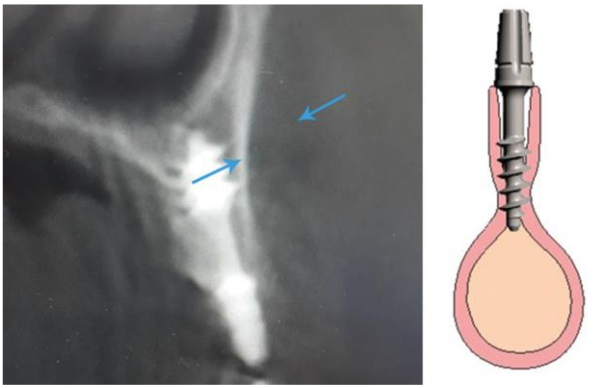

Figure 14: Anchorage from the cortical bone on the buccal and lingual

Method 7

Method 7a

Anchorage can be achieved by penetration of the implant into the nasal floor (Figure 15). The implant is inserted through the maxillary alveolar bone. This technique may involve penetration of the nasal mucosa resulting in the polished implant surface and eventually part of the grooved area being able to extend slightly into the nasal floor.

Method 7b

It can be applied to the palatinal side of the severely horizontally atrophied alveolar bone (knife-edge maxilla) without penetrating the alveolar bone and by directing the implant directly towards the nasal floor. Method 7b is a special application technique based on Method 7a.

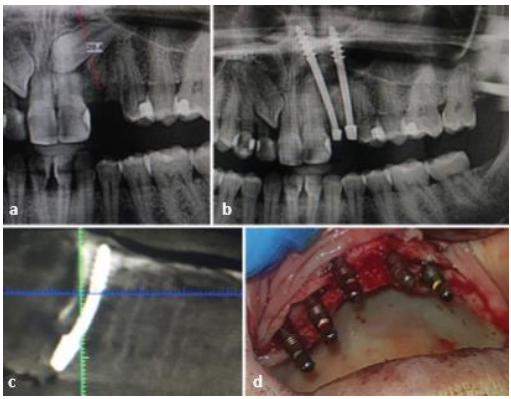

Figure 15: *a. Preoperative panoramic image b. Panoramic image after the embedded canine was removed and the implants were applied c. Radiographic image of the corticobasal implant penetrating the nasal floor from the palatine of the atrophic maxillary alveolar bone d. Intraoral image after the implants were applied*

Method 8

Method 8a

Anchorage can be provided from the cortical bone at the base of the maxillary sinus (Figure 16).

Method 8b

The intrasinusional septum can also be used for multicortical anchorage of the corticobasal implant, including penetration of part of the implant groove into the maxillary sinus.

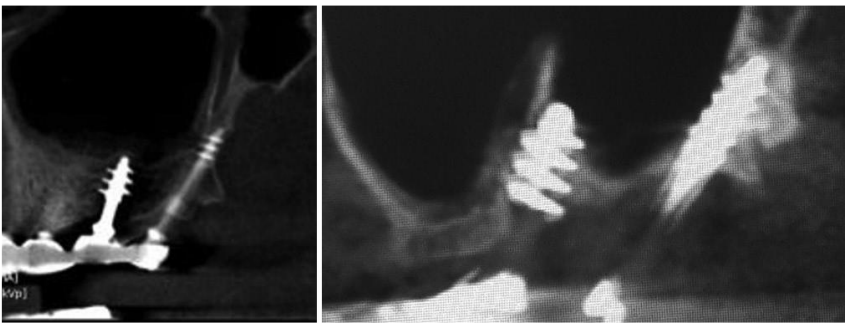

Figure 16: Anchorage through the maxillary sinus septum for multicortical anchorage

Method 9

Method 9a

By bypassing the upper canine root, the implant is positioned in the cortical bone of the nasal floor, the abutment head is positioned in the first or second premolar area and the shaft of the implant is anchored to bypass the canine root on the palatal side (Fig. 17). Method 9 is a special case of Method 7a or 7b.

Method 9b

The abutment head is positioned in the first or second premolar area bypassing the upper canine root and the implant is anchored to the median raphe of the maxilla so that the shaft of the implant bypasses the canine root on the palatinal side.

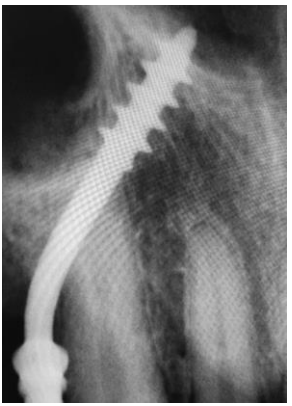

Figure 17: Bypassing the maxillary canine root and providing anchorage from the cortical bone at the nasal floor

Method 10

Method 10a

The apical grooves of the implants can be inserted into the cortical bone of the pterygoid process of the sphenoid bone (Fig. 18), either directly into the pterygoid process of the sphenoid bone or through the maxillary tuberosity and/or maxillary sinus. In an optimal final position, the apex of the implant penetrates the internal pterygoid muscle (between the wings of the pterygoid process), thus increasing anchorage by compression of the pterygoid plate. For this method, Corticobasal® implants or designs with a compression effect are applied.

Method 10b

Double tubero-pterygoid implants are placed at the junction between the distal maxilla and the sphenoid bone at parallel or slightly diverging angles.

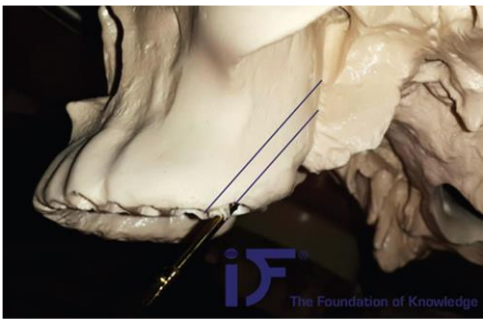

Figure 18: Application angles of the tubero-pterygoid implant

Method 11

Method 11a

Anchorage can be obtained from the cortical bone in the palatinal aspect of the maxillary sinus without penetration of the nasal floor or median raphe of the maxilla (Figure 19).

Method 11b

The implant can be anchored laterally to the median raphe of the maxilla.

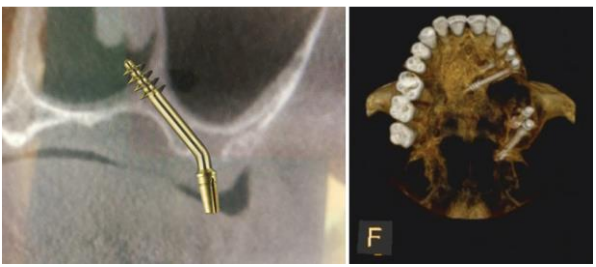

Figure 19: a. Anchorage through the palatinal wall of the maxillary sinus b. Anchorage through the median raphe of the maxilla

Method 12

Anchorage of the implant in the body of the zygomatic bone: It can be placed directly into the body of the zygomatic bone using a trans-sinusally procedure or extra-sinusally (Fig. 20).

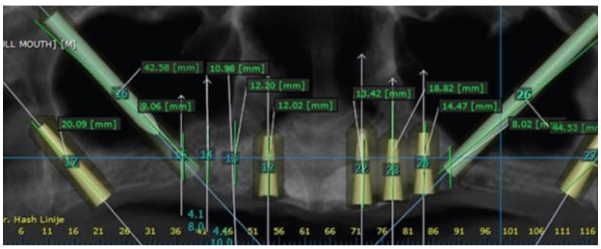

Figure 20: Anchorage through the zygomatic bone body

Method 13

Placement of vestibular implants in the knife-edge crests of the anterior mandible. Typical implant diameter is 2.7 mm or 3.0 mm. Anchorage can be obtained at the base of the mandible. The smooth vertical parts of the implant run partly subperiosteally. The anterior caudal cortex can also be used for this type of implant anchorage, but care must be taken not to damage the nearby blood vessels and planning for long-term preservation of the oral mucosa to cover the vertical implant supports (Fig. 21).

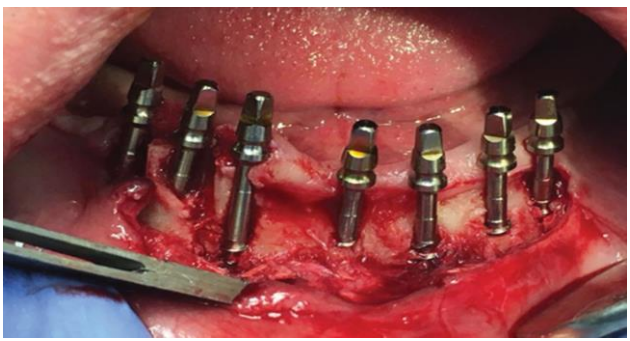

Figure 21: Application of a vestibular implant in the anterior region of the mandible. Smooth implant surfaces work like subperiosteal.

Method 14

The implant can be anchored with support from at least one mesial or distal cortical bone in the fresh extraction socket of the first or second premolar (Fig. 22). Using the lingual cortical bone of the

mandible increases anchorage. The vestibular cortical bone of the mandible has the same structure as the lamina cribrosa of the extraction socket. Therefore, the lingual cortical bone is considered permanent.

Figure 22: Anchorage from the lingual bone in cases with immediate implant application after extraction

Method 15

Anchorage can be achieved by using a larger diameter implant in the fresh extraction socket of the palatinal root of the upper first or second molar (Fig. 23). The implant should penetrate the maxillary sinus wall to provide maximum resistance to intrusive and extrusive forces.

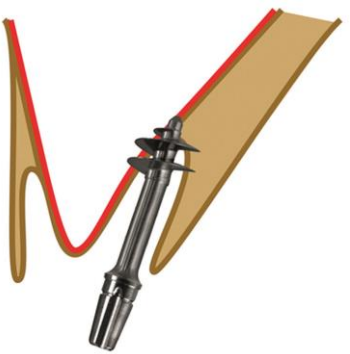

Figure 23: Penetration of the apical part of the implant into the sinus wall by applying the implant to the palatinal root after maxillary molar extraction

Method 16

Two implants can be placed in the region of the upper first premolar. One implant is placed palatally at the base of the nasal cavity (canine root bypass, Method 9), while the other implant is placed in the vestibular root socket of the first premolar. If pterygoid implants cannot be placed, 2 or 3 implants can also be placed in the maxillary first and second molar region in this way (Fig. 24).

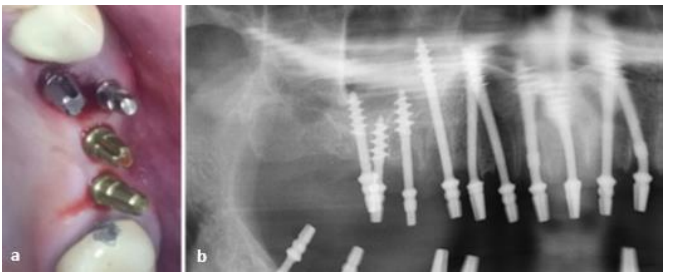

Figure 24: a. Application of two corticobasal implants buccally and lingually in the maxillary first premolar tooth region b. Radiographic image after application of 2 separate implants to the roots in the maxillary molar tooth region

COMPLICATIONS

- Rupture of palatinal vessels during the application of pterygoid implants
- Bleeding or drill breakage in implant applications anchored from the nasal floor
- Breakage of the drill during preparation of the pterygoid implant socket
- Intraoral and extraoral ecchymosis occurring immediately after surgery, usually disappearing within 1-2 weeks
- Decreased mouth opening after pterygoid implant placement due to damage to muscle fibres, which gradually returns to normal

- Postoperative loosening of the prosthesis due to porcelain separation from the metal substrate and desimantation
- Shahed et al. reported that basal implants can lead to submucosal infection. If implants are positioned below the mucosal level over time, the passage for suppuration is eliminated as the penetration site is covered by scar tissue, which can result in infected vertical portions. Any inflammation of this type spreads in the same way as a submucosal abscess and is treated in the same way (Shahed et al., 2018).
- Osteolysis due to overloading around a single implant due to high occlusal contact (Patel et al., 2021)

CONCLUSION

The use of corticobasal implantology is increasing day by day with improving implant design and technologies. Appropriate case selection, atraumatic extraction, primary stability and anchorage from the second or third cortical bones, rigid prosthesis production with the occlusion concept outlined by Dr. Ihde, equal bilateral chewing and lingualised occlusion, maintenance of good oral hygiene and routine follow-up at regular intervals are very important in the long-term survival of corticobasal implants (Ihde, 2005).

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FIGURES:

Figure 1: a. KOS b. BCS c. KOS Plus Implant

Figure 2: a. Basal Osseointegrated Implant (BOI) b. Bicortal Screw Design (BCS)

Figure 3: a. Compression Screw Design (KOS) b. Compression Screw and Bicortical Screw Design (KOS Plus)

Figure 4: Bone Multicellular Unit (BMU). The resorption zone is composed of osteoclasts, followed by a recharge zone composed of osteoblasts, and the region in between is called the reversal zone.

Figure 5: Corticalisation of the implant-bone interface in the osseointegration approach

Figure 6: Formation of the mineralisation zone by compression of the spongiose bone

Figure 7: a. Cortical interaction directly from the buccal and lingual bone b. Cortical interaction directly from the apical basal bone

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Figure 12: Bypassing the inferior alveolar nerve

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Figure 14: Anchorage from the cortical bone on the buccal and lingual

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BÖLÜM IV

Lasers in Oral and Maxillofacial Surgery

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Gizem Sena DEMİRKIRAN[2]
Efe Deniz COŞGUNER[3]
Betül Sena UNCU[4]

Introduction

Lasers have been used for many years in dentistry. In the past, they had a limited range of applications but nowadays, laser systems and their applications have been advancing rapidly. In this chapter, laser usage in dental surgery will be discussed. However, prior to this topic, it is crucial to learn basic principles of laser

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technology to understand the use of lasers in oral and maxillofacial surgery.

LASER is an acronym for light amplification by stimulated emission of radiation (Gross & Herrmann, 2007). Laser systems contain an energy provider, an active medium composed of electrons that will be induced to produce activated photons and a resonator that consists of two or more mirrors. The energy provider can be an electrical coil, light pumping or another form of energy. Briefly, an external energy source pumps the energy into the active medium and starts the excitation process. As a result, spontaneous emission of photons is produced. After that, photons are transmitted back and forth via the medium by optical resonator and this process leads to amplification. (Verma et al. 2012). When the stimulated emission process continues, a laser that is highly collimated, coherent and monochromatic is produced. Monochromatic describes electromagnetic radiation of a single wavelength, equal energy level and frequency, coherent, which describes features of light waves that preserve a stable phase relationship; and collimated means that all light waves are parallel to each other (Luke et al., 2019). These features distinguish the laser from other light sources and provide specific application areas like medicine and dentistry. It is very important to know laser tissue interactions to perform successful laser treatment. Laser tissue interactions are reflection, scattering, absorption, and transmission.(Fig.1)

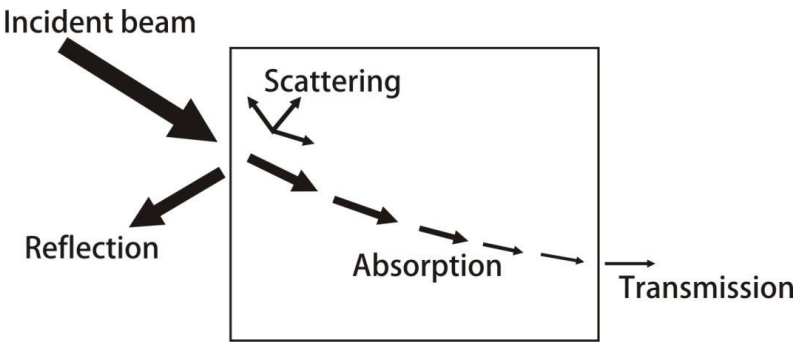

Figure 1 . The laser tissue interaction (Zezell et al., 2011) (4))

Incident rays return from a reflective surface that is generally barrier between two mediums with different refractive index and that is called as reflection (Niemz, 2019). Absorption takes place when electromagnetic waves are not turned back. In an opaque medium, energy of the incident radiation is reduced and it is converted into some other form of energy like heat and kinetic energy. However, incident light goes through the transparent medium with no absorption and energy loss. Absorption of lasers is necessary to obtain biological effects. When incoming light frequency doesn't equal the frequency of tissue, scattering occurs. (Zezell & Ana, 2015). Laser tissue interaction is affected by laser system properties like wavelength, energy, duration, frequency of pulse, and tissue characteristics, such as the refractive index, scattering coefficient (μs), absorption coefficient (Ana & Bachmann & Zezell, 2006). As a result, laser systems must be selected specifically for the procedure to be performed.

Lasers Classification

Dental lasers have been categorized by the physical construction of medium, tissue applicability, power and wavelengths.

Table 1. Classification of Laser (Zezell & Ana, 2015), (Priya et al., 2014)

LASER	**CONSTRUCTION**	**WAVELENGTH (nm)**	**TISSUE APPLICABILITY**
CO2	Gas	10600	Soft tissue surgery
ARGON	Gas	488/514	Soft tissue surgery
Er:YAG	Solid	2940	Hard tissue ablation
Er,Cr:YSGG	Solid	2780	Hard tissue ablation

Nd:YAG	Solid	1064	Soft tissue surgery
DIODE	Semiconductor	810/940	Soft tissue surgery

CO2 Lasers

Carbon Dioxide lasers are hydrophilic due to their wavelength. They can be used in soft tissue surgery such as frenectomy, excisional biopsy, etc. Also, hemostasis can be achieved with CO2 lasers. However, CO2 lasers have some disadvantages such as their great size and high cost. (Garg et al., 2015).

Argon Lasers

Argon Lasers are especially used in restorative dentistry such as composite resin placement, preventive dental procedures, dental bleaching, etc. (Kelsey & Blankenau & Powell, 1991). Also, argon lasers can be useful in soft tissue removal like venous malformation or hemangioma. (Sexton & O'hare, 1993).

Erbium Lasers

Erbium hard tissue lasers have the ability to not only cut soft tissue but also they can be used in enamel, dentin, cementum, and bone due to their strong attraction to hydroxyapatite and the highest absorption of water. Erbium lasers have demonstrated significant advantages in restorative dentistry. These include painless cavity preparation and caries removal, modifications to enamel and dentin for bonding purposes and elimination of smear layers. (Strakas & Gutknecht, 2018). Also, erbium lasers have various application areas in oral and maxillofacial surgery. They can be useful in hard tissue surgery like harvesting autogenous block grafts (Stübinger et al., 2008). On the other hand, soft tissue surgery like frenectomy, implant exposure or removal of soft tissue lesions can be made by erbium lasers (Van As, 2004)

Nd:YAG Lasers

The Nd:YAG laser exhibits high absorption by pigmented tissues, rendering it an succesful laser for soft tissue surgery, providing effective hemostasis (Verma et al., 2012).

Diode Lasers

Wavelengths of diode lasers range from 810 nm to 980 nm. Active mediums of diode lasers include aluminum, gallium, arsenide, and sometimes indium. They are absorbed by tissue pigmented such as melanin and hemoglobin and poorly absorbed by hydroxyapatite and water. Dental surgeons can benefit from diode lasers in soft tissue surgery due to effectiveness in coagulation, minimizing the need for sutures, reduced pain and swelling. Also, they have the ability to treat physiologic gingival pigmentation. (Azma & Safavi, 2013).

As mentioned before, lasers are also classified by their power: high power lasers and low power lasers. High-power lasers produce an energy equal to or higher than 1 W/cm2, and they lead to an increase of temperature 1 °C or more in tissues. Rising in temperature facilitates processes such as coagulation, cutting, vaporization, or tissue ablation. In contrast, a few mW/cm2 power is generated by low power lasers. Low level laser therapy is based on non-thermal effects (photophysical, photochemical, and photobiological) and the temperature of biological tissue does not exceed 37.5 °C (Zezell & Ana, 2015). High power lasers have an ability to produce energy more than 500 mW. They produce heat and cause healing effects through thermal interactions. They are commonly used in hard and soft tissue surgery. Low power lasers are also known as cold lasers. Low level lasers generate energy less than 500 mW. They help curing of tissue, decrease inflammation, edema, pain (Priya et al., 2014). They enhance ATP synthesis and cell proliferation.Also, they induce antiedematous, anti-inflammatory, angiogenic and analgesic responses of tissue.(Zezell & Ana, 2015).

Another laser classification can be made according to wavelengths. Argon, Diode and He-Ne lasers are within the visible spectrum of light. Other dental laser devices are in the infrared portion of the electromagnetic spectrum. Short wavelength lasers in the near infra-red spectrum are useful in soft tissue surgery because they have minimal or no interaction with the dental hard tissues..These soft tissue procedures can be frenectomy, operculectomy, implant uncovering, oral biopsy, etc. Lasers that have longer wavelength show high absorption coefficient of water. The lasers under this category, Er, Cr:YSGG, Er:YAG and CO2 lasers and they are effective in the periodontal pocket debridement, in the treatment of periimplantitis as well as osteotomy and restorative procedures. (Pandarathodiyil & Anil, 2020).

Applications of Lasers in Oral and Maxillofacial Surgery

Lasers in Soft Tissue Surgery

Lasers have various application areas in soft tissue surgery such as frenectomy, operculectomy, surgical removal of gingival overgrowth, incisional and excisional biopsy, second-stage surgery of submerged dental implants, etc. They have several advantages in soft tissue surgery. Lasers are user-friendly and provide a better surgical experience. They promote effective coagulation, helping to control bleeding during procedures and contributing to improved surgical outcomes. Also, lasers significantly reduce the requirement for sutures in soft tissue surgery, facilitate healing and increase postoperative comfort. Lasers decrease swelling, pain and potential for postoperative bacterial contamination. (Azma & Safavi, 2013), (Parker, 2007). However, there are also some disadvantages such as high cost, heat generation, and potential for tissue damage. Lasers can cause thermal defects and minor loss of histological architecture in excisional biopsy of oral lesions. (Kashyap, et al. 2018).

Lasers in Hard Tissue Surgery

Lasers can be used for hard tissue surgery. Surgical removal of impacted teeth can be performed by hard tissue lasers such as

erbium lasers. Postoperative pain and swelling are less than conventional methods. (Peen & Nguyen & Hong, 2019). Also, osteotomy lines can be made by Er: YAG lasers but lack of depth control and requirements of experience are limitations of laser osteotomy.(Stübinger, et al. 2009). Laser osteotomy can be an alternative method for preparing implant sites. In addition, in some studies, Ho:YAG lasers have been discussed as potentially applicable in temporomandibular joint arthroscopic surgery; however, it requires advanced arthroscopic surgical skills and a high level of experience in laser surgery. (Koslin, 2004).

Low Level Laser Therapy Applications in Oral and Maxillofacial Surgery

Low level laser therapy (LLLT) has been used for accelerating wound healing in soft and hard tissue. LLLT is effective in vasodilation and increasing local blood circulation. Vascular dilation induces blood flow and immune cell migration to the tissues. This process increases tissue repair rate (Rathod et al., 2022).

LLLT can modulate the inflammatory response by reducing pro-inflammatory mediators production. LLLT can contribute to a reduction in swelling and tissue inflammation after oral surgeries. Also, LLLT has analgesic effects by inducing the synthesis of endogenous endorphins (β-endorphin), reducing the activity of bradykinin and C fibers and altering the sensitivity to pain. (Fabre, et al., 2015). In addition, some researchers claimed that LLLT after impacted tooth extraction reduces postoperative trismus but further studies are needed. (Ferrante, et al., 2012).

LLLT can be helpful for implant osseointegration procedures. It can be an effective technique to increase the bone healing rate. LLLT has been shown to have biomodulatory effects on wound healing, fibroblast proliferation, and collagen synthesis. For this reason, it enhances osteoblast activity and new bone formation and induces an osseointegration process. (Pyo SJ. et al., 2013).

Laser technology has made great progress over the decades. Therapeutic laser techniques are predicted as a future growth area, and specific laser technologies are expected to become essential components in contemporary dental practices in the next decade. Despite these advancements, further studies are considered necessary to fully understand and utilize the potential of laser treatment in these areas.

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BÖLÜM V

Björk Cephalometric Analysis on CBCT with Balanced Facial Type

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INTRODUCTION

With the development of the Cone Beam Computerized Tomography (CBCT) method, a new imaging technic has been introduced in this area. Progress in technology has made it possible to switch two-dimensional (2D) cephalometric to three-dimensional (3D) cephalometric analyzes. In this respect, the limitations of 2D cephalometrin could be removed. The ability to evaluate images

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from three planes has the advantage that images can be obtained at actual dimensions without distortion or superposition (Cevidanes vd., 2009:94-99).

Arne Björk is one of the researchers who made a great contribution to the achievement of the cephalometric analysis today. Björk's intention is to examine the prognatism and the parts that affect the whole of the face. By Björk, prognatishm is defined as prominence of face in relation to skull (Björk, 1947:121) The purpose of this study is to evaluate Björk's analysis, which has been used for many years in orthodontic practice, using distortion free and unmagnified data presented us by 3D imaging. In our study, Björk (1947:121) analysis was performed on CBCTs from subjects with the same region, neutral closing and balanced facial profile, and the results were compared with Björk data.

MATERİAL-METHODS

Our study was carried out at the Faculty of Dentistry of Kırıkkale University with the permission of Kırıkkale University Non-Interventional Research Ethics Committee dated 2021.02.01, numbered 2021/04. The material of our study was selected in accordance with the criteria set out among the CBCT records of subjects who applied to an imaging center for diagnostic or other purposes. The number of selected tomography was 150.

Inclusion criteria: Subjects aged 18-30 were included in the study (craniofacial growth completed). CBCT images were evaluated by an orthodontist. These who were determined to have a balanced facial appearance, did not show a significant deviation of the facial and dental midline and those who had maximal intercuspidation of the teeth were included in the study. Exclusion criteria: Those with severe asymmetry, known craniofacial syndromes, any fixation screws or plaques in the face area, tooth loss (except for third molars) and orthodontic treatment history were not included in the study. A total of 150 subjects, 63 male and 87 female, were included in our study.

CBCT images were obtained when subject was in the sitting position and his/her head was fixed in position and the midsagittal plane is perpendicular and the Frankfurt Horizontal plane is parallel to the plane and the teeth are in a state of maximum intercuspansion. CBCT images were produced by ILUMA, IMTEC (Europa, Oberursel, Germany). The voxel size of the tomography device is 0.3 mm. The device operates at 120 kVp and 3,8 mA current. CBCT scanner rotate around subject's head in a complete 360 degrees and scan 8×14 cm area for an average of 40 seconds. The data prepared by ILUMA Vision program (DICOM formatted) which contained 150 patients constituting the study group were transferred to the computer where Dolphin Imaging 11.8 software was installed. Orientation was made in three planes by entering the "Orientation" option to bring the image to the desired orientation.

The cephalometric analysis was constructed from the Björk analysis. Definitions of the anthropological points and measurements used for the analysis on the three-dimensional imaging are given in the Table 1 and 2.

Table 1. *Definitions of antropological points.*

Points	**Definitions**
Nasion (Na):	Axial and sagittal views of frontonasal sutura at the front, coronal image at the midpoint
Sella (S):	Sagittal, geometric midpoint of Sella Tursica in axial and coronal images
Articulare (Ar):	The point where the condyle head intersects the head scapular in the sagittal view, the convex point of the condyle head in the axial view
Gonion (Go):	In the sagittal image, the angle of the angle of the angle of the angle formed by the corners of the corpus and the ramus, the angle of the corpus in the axial view, and the lowest point of the ramus in the coronal image
Menton (Me):	The lowest point of the mandible in sagittal and coronal images, and the most central point in the axial view.

As a result of the power analysis performed to test the adequacy of the number of samples used in our study, it was determined that the sample number of 100 persons will have an effect size of 0.5% and a power of 98% at the significance level of α0.05.

The Shapiro-Wilk test was applied to evaluate whether the measurements used in our study were normal or not, and it was determined that all of the parameters examined in the study showed normal distribution. Independent T-test was used for the parametric tests in the comparison of the variables. In order to evaluate the intra-observer reliability of the method error-checking results on the reproducibility of three-dimensional cephalometric measurements, the measurements of 30 randomly selected subjects were repeated by the same investigator about 1 month after the first drawings. Intraclass Corelation Coefficient (ICC) was calculated to test the reliability. ICC values ranged from 0.947 to 0.986 and high reliability was determined between measurements. In Björk's study (1963: 400-411), the difference between the values obtained on the male population and the values of the male population in our study was evaluated by unpaired t test.

Table 2. *Definitions of measurements*

Anguler measurements	**Definitions**
N-S-Ar (Saddle (Sella) Angle)	The angle formed at the Sella point between the front skull base and the rear skull base.
S-Ar-Go (Articular Angle)	The angle formed at the Articular point between the Sella-Articulare-Gonion points.
Ar-Go-Me (Gonial Jaw Angle)	Angle between articulare, gonion, mentone.
Na-Go-Me (Lower Gonial Angle)	The angle between nasion, gonion, mentone.
Ar-Go-Na (Upper Gonial Angle)	The angle between articulare, gonion nasion
SUM of Angles	Sum of the sella, articular and gonial angle.

Longitudinal measurements	
Ar-Go (Ramus Height)	Distance between Ar and Go points.
S-Ar (Posterior Cranial Base)	Distance between the S and Ar points.
Na-S (Anterior Cranial Base)	Distance between the points S and Na.
Go-Me (Mandibula corpus Lenght)	It is the length of the mandible corpus. Distance from Go to Me.

RESULTS

In our study, CBCT images of 150 subjects, 63 males and 87 females were used. The mean age and gender of the subjects are given in Table 3.

Table 3. Age and gender of subjects

	Average Age	**n**
Women	21.95 ± 4.19	87
Men	23.31 ± 4.72	63
Total	22.52 ± 4.45	150

The subjects included are between the ages of 18-30. There was no statistically significant difference in terms of the mean age among the sexes, thus subjects were considered as one group (adult).

Comparing the values of male and female individuals, male's Anterior Cranial Base (Na-S) mm, Ramus Height (Ar-Go) mm, Posterior Cranial Base (Ar-Go) mm, Mandibula Corpus Lenght (Go-Me) mm values were higher than female's .In angular measurements, no significant difference was found between male and female individuals. (Table 4)

Table 4. Minimum, maxiumum and mean values of male and female subjects.

	M:63 F:87	**Mean**	**Std. Deviation**	**Std. Error Mean**	**95% Confidence interval**	**P**
Saddle (Sella) Angle (N-S-Ar)°	M	125.99	5.82	.73	-3.12 - .96	.298
	F	127.07	6.54			
Articular Angle (S-Ar-Go) °	M	143.16	8.99	1.13	-2.28 - 4.37	.535
	F	142.12	10.96			
Gonial Jaw Angle (Ar-Go-Me) °	M	121.45	8.02	1.01	-4.24 - 1.25	.284
	F	122.95	8.69			
Upper Gonial Angle (Ar-Go-Na) °	M	48.48	4.36	.55	-2.37 - 1.08	.464
	F	49.13	5.87			
Lower Gonial Angle (Na-Go-Me) °	M	73.10	5.24	.66	-2.40 - .88	.363
	F	73.86	4.86			
Sum of Angles	M	390.64	5.85	.73	-3.25 - .25	.093
	F	392.14	4.97			
Anterior Cranial Base (Na-S) mm	M	69.12	3.51	.44	3.38 - 5.50	.000***
	F	64.67	3.01			
Ramus Height (Ar-Go) mm	M	54.05	5.05	.63	2.64 - 5.66	.000***
	F	49.90	4.26			
Posterior Cranial Base (Ar-Go) mm	M	31.54	3.70	.46	1.92 - 4.26	.000***
	F	28.45	3.48			
Mandibula Corpus Lenght (Go-Me) mm	M	70.13	4.35	.54	2.25 - 5.39	.000***
	F	66.30	5.10			

The data of the Björk study (1963: 400-411), (281 subjects) and the data of male subjects in our study (63 subjects) were compared. Saddle (Sella) angle was found higher in Turkish male

subjects, articular angle, gonial jaw angle, sum of angles, anterior aranial base are higher in and ramus height is lower in Swedish subjects (Table 5).

Table 5. Comparison of Björk's data and data from our study.

	Björk (281)	**Turkey (63)**	**Mean Difference**	**95% Confidence Interval**	**p**
Saddle (Sella) Angle	123±5	125.99±5.82	0.71	-4.40 - -1.57	. <0.001***
Articular Angle	143±6	143.16±8.99	0.82	-1.78 -1.46	0.846
Gonial Jaw Angle	130±7	121.45±8.02	1.00	6.57 - 10.52	<0.001***
Upper Gonial Angle	50±2	48.48±4.36	0.36	1.28- 2.71	<0.001***
Lower Gonial Angle	80±5	73.10±5.24	0.70	5.51-8.28	<0.001***
Sum of Angles	396±5	390.64±5.85	0.72	5.94-8.77	<0.001***
Anterior Cranial Base	71±3	69.12±3.51	0.43	1.03-2.72	<0.001***
Ramus Height	44±5	54.05±5.05	0.69	-11.42- -8.67	<0.001***
Posterior Cranial Base	32±3	31.54±3.70	0.43	-0.40-1.32	0.29
Mandibula Corpus Lenght	71±5	70.13±4.35	0.68	-0.47- 2.21	0.20

DISCUSSION

Lateral cephalometric analyzes are widely used to establish guidelines that assist in orthodontic diagnosis and treatment planning. Studies on three dimensional cephalometric images obtained with CBCT together with developing technology have started to take place in the literature. Results supporting the reliability of CBCT have been obtained in studies conducted to evaluate the accuracy of cephalometric measurements (Oz vd., 2011:492-500) In Turkey, Björk cephalometric analysis on CBCT has not been studied in the adult population.

Classifications based on cephalometric measurements provide scientific communication between orthodontists, such as the Angle classification. In general, cephalometric analyzes are based on some assumptions. Experiences gained over time help to question the assumptions of the analysis and the strengths and weaknesses of them. The point that orthodontists should pay attention to is which of the cephalometric norms the subject should be assessed for, which is important to which population the subject belongs; thus making the ideal treatment plan more appropriate for the subject (Bayome vd., 2013: 62-73).

In our study, the sample consisted of subjects with neutral closure that did not require orthodontic treatment. For each subject, 6 angles and 4 linear measurements were calculated on the 3D CBCT images.

Regarding the results obtained, it was found that the sella angle was slightly higher in female subjects. It is strongly related to facial height. If the angle is small, the mandibular joint is positioned at the front (Björk, 1963: 400-411). We have found that the angle of the sella is broader in females than the males. The wide angle sella means that the condyle is positioned backwards. Thus a retrognathic profile appears. This gender characteristic was also reported by other researchers (Pecora vd., 2008: 496-505; Rodriguez-Cardenas vd., 2014: 46-53) . In our study, there was no significant difference between the genders in terms of articular and gonial angle, consistent with the findings of Baccetti et al (Baccetti vd., 2005: 510-520). Sum of posterior angles are also higher in female. This elevation has been associated with retrognathism by Björk (Björk, 1963: 400-411).

Björk's aim was to examine the prognostic prognatism and the factors affecting it in his study of 65 parameters, 34 angular 31 linear. By Björk, prognatishm is defined as prominence of face in relation to skull (Björk, 1947:121). The values we obtained were found to differ from each other when compared with the mean values determined by Björk. In 1943 Björk went to military units with portable x-ray equipment and obtained a cephalogram from 281

soldiers aged between 21 and 23 years. He did not include subjects with a prosthesis in his mouth, a large number of tooth loss and orthodontic treatment history (Björk, 1947:94-97). All the subjects in the study group were Swedish. We sampled subjects who had no tooth loss, had no orthodontic treatment, and had no prosthesis or fixation. We used only the data of male subjects when comparing with the Björk standards because the sample was composed of male subjects in the Björk study (Table 5).

According to Björk, reductions in the sella angle indicate that the mandibular joint is positioned anterior (Björk, 1963: 400-411). As a result, the jaw bone is positioned anterior and the prognatishm angles are increasing. Thus, the prominence of facial skeleton in relation to skull is increasing. In our findings, this angle was higher than the Björk norms. Based on this knowledge, it can be said that subjects in Turkey are more retrognathic than the subjects in Björk study. According to Björk, the lower and upper gonials are significant in determining the direction of development of the lower jaw. When the upper gonial angle is large and the lower gonial angle is small, development direction of mandible will be forward and upward (Björk, 1963: 400-411). These two angles are smaller in subjects in Turkey and it is especially smaller for the lower gonial angle.

Reductions in the anterior cranial and posterior cranial distances create a significant increase in the prognathic direction reported Björk. In our findings, this value is smaller than the Björk values. However, due to the magnifications in the millimetric measurements made on X-ray, we think that higher values than CBCT are obtained. According to Björk, the sum of sella, articular and gonial angles is of the parameters that define the growth pattern in an subject. The estimated value for a person with neutral growth is 396 ± 6 (Björk, 1963: 400-411). Higher values than this may cause excessive hyperdivergent facial development. In our study, the sum of posterior angles was found to be lower (391 °). We can say that subjects in Turkey tend to have hypodivergent face.

In angular measurements we have shown that skeletal changes are similar in male and female groups. Ceylan and Gazilerli (1992: 143-152), Baturay and Erdogan (1977: 55-62) in their study of using two-dimensional imaging on adults in Turkey, reported that they did not find a statistically significant difference in gender between angular measurements and therefore did not need to establish separate standard values for male and females. In our study, linear craniofacial measurements showed significant differences in male and female samples, with no significant differences in angular measurements. Significant difference in linear measurements and no significant difference in angular measurements in other three-dimensional analysis studies are similar to our results (Bayome vd., 2013: 62-73; Cheung vd., 2011: 56-73; Devanna, 2015: 30-37).

Our findings show that higher sella angle in women affects the height of the face and has a retrognathic reflection in the dentofacial skeleton.

Işımer et al. (1990: 65-71) compared the norms of 52 adult subjects with neutral occlusion to Björk norms using two-dimensional imaging. The anterior cranial base length, posterior cranial base length, mandiular length, sella angle and articular angle values they reported were similar to Björk values; but that the ramus length is larger and the gonion angle is smaller. For this reason, it is advisable to use their own norms for these two parameters. This data is consistent with our findings (ramus height: 54 mm, gonial angle: 121).

CONCLUSION

In our study, Björk cephalometric analysis on CBCT obtained from subjects with balanced facial profile and neutral occlusion were generated. These results show that the millimetric values are lower because the magnification is eliminated by three-dimensional imaging when compared with Björk values. Referring to the differences in angular measure, we can say that subjects in Turkey are more hipodivergant and retrognathic than Swedish

population. Females have retrogenic and smaller facial structures than males.

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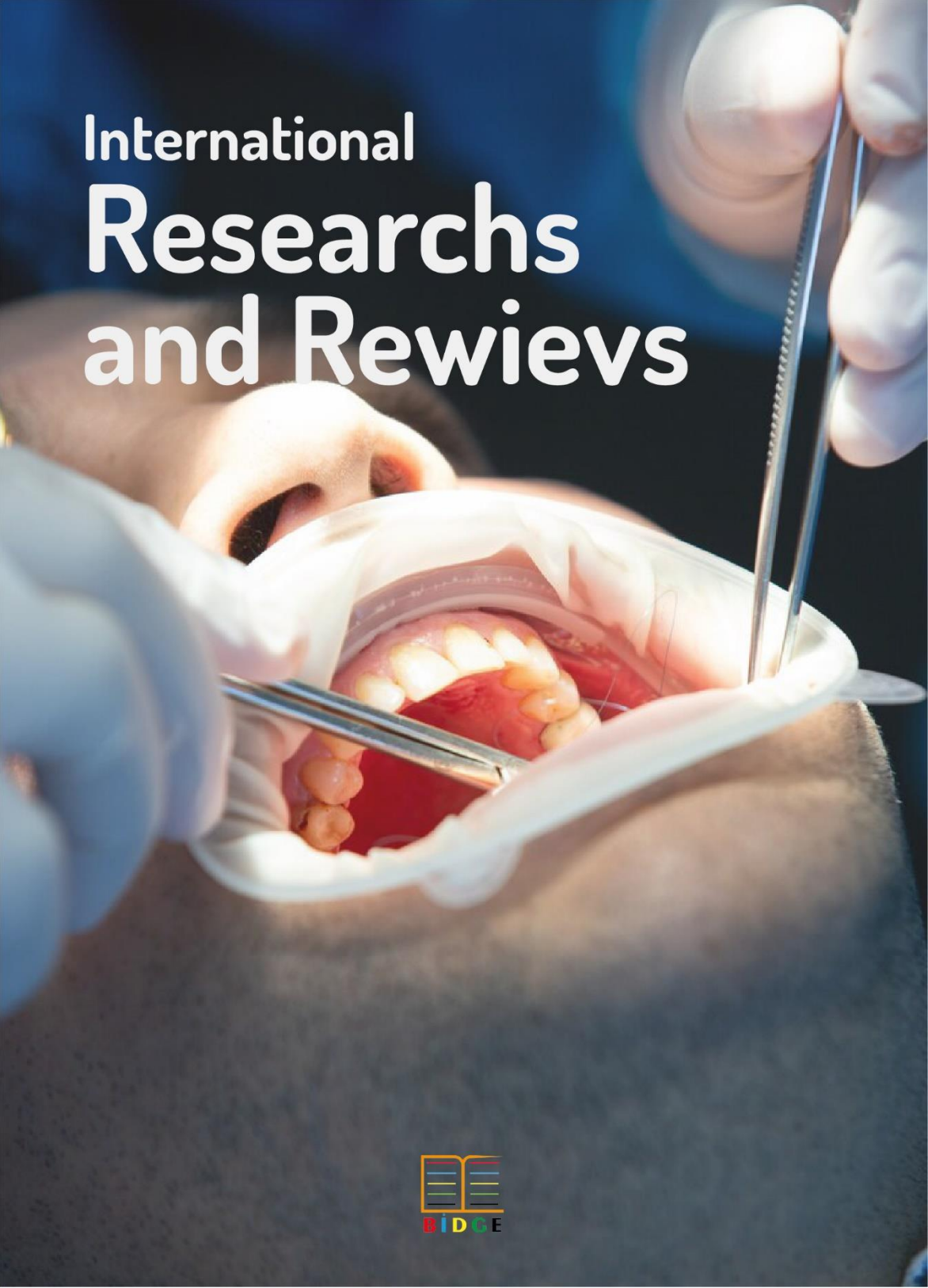

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