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Innovation in DENTISTRY

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Prof. Dr. Övül Kümbüloğlu

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**in**

# DENTISTRY

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web: www.ivpe.me

Tel. +382 41 234 709

e-mail: office@ivpe.me

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# PREFACE

Dentistry is a multidisciplinary branch of science including many professions such as medicine, architecture and fine arts. Aesthetics, which is a branch of philosophy examining the beauty and nature of fine arts, is irreplaceable for dentistry as well. Opening the doors of modern dentistry world, it can be seen that the implant therapies and digital dentistry systems provide advantages not only in terms of visuality, but also in time efficiancy and comfort.

With the development of technology, "innovation" is at the forefront in every discipline of dentistry. In this book, we tried to include innovations from various branches of Dentistry for the readers. I sincerely thank everyone who contributed.

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Prof. Dr. Övül Kümbüloğlu, Ege University, Turkey

Doç. Dr. Ayşe Dina Erdilek, Istanbul University, Turkey

Doç. Dr. Serkan Dündar, Fırat University, Turkey

Doç. Dr. Zeliha Uğur Aydın, Bolu Abant izzet Baysal University, Turkey

Dr. Öğr. Üyesi Ayşegül Kurt, Trakya University, Turkey

Dr. Öğr. Üyesi Gülfeşan Şanakçı, Trakya University, Turkey

# CHAPTER I

# A DIFFERENT PERSPECTIVE ON BRUXISM

Specialist Dr. Duygu BİLGİLİ

Fenerbahçe University Vocational School of Health Services, Oral and Dental Health Associate Program, Istanbul, Turkey,
e-mail:duygu.bilgili@fbu.edu.tr, Orcid ID:0000-0002-1900-543X

Bruxism is a repetitive jaw-muscle activity characterized by clenching, grinding, and gnashing of the teeth (Lobbezoo et al., 2013; Dent, 2005). Bruxism is an involuntary, parafunctional oral habit that may lead to occlusal trauma (Dent, 2005). Bruxism is classified into two groups: Awake bruxism and sleep bruxism (Lobbezoo et al., 2013). Sleep bruxism is observed during non-REM and REM sleep phases. Although sleep bruxism attacks are distributed equally to REM and non-REM phases, the duration of sleep bruxism extends during the non-REM phase, because 82% of time spent sleeping consists of non-REM sleep (Macaluso et al., 1998). Prevalence of bruxism is 20% among the adult population (Kulis & Türp, 2008; Lavigne et al., 2008). Nonetheless, only 8% of the population are reported to have sleep bruxism (Lavigne et al., 2008). Bruxism may also occur in children (Manfredini et al., 2013; Widmalm et al., 1995). Sleep bruxism can be observed at rates of 3.5 to 40.6% depending on age group and self-reporting (Manfredini et al., 2013). On the other hand, the prevalence of bruxism can decrease with increased age (Hublin et al., 1998; Widmalm et al., 1995). When the frequency of bruxism for each sex is examined, awake bruxism is more common among females than males (Shetty et al., 2010). However, sleep bruxism does not discriminate between individuals (Feu et al., 2013; Hublin et al., 1998; Shetty et al., 2010).

Bruxism has many negative effects on oral and environment tissues. Chips and fractures may be observed on the tubercle, root, and crown when these forces caused by clenching are greater than the endurance of enamel and dentin (Torabinejad & Walton, 2011). Bruxism has been shown to cause tooth wear, tooth mobility, opening of contacts, failure of implants, damage to restorations, linea alba, recess on the lip or tongue, dental intrusion, inflammation, pulpal alterations (e.g., pulp necrosis), widening of periodontal ligament, periapical pathoses, root resorption, bone loss, periodontal diseases, tooth pain and sore masticatory muscles, temporomandibular dysfunction, headache, neck and shoulder soreness, etc (Chrcanovic et al., 2016; Harn et al., 2001; Hülsmann & Schafer, 2014; Kaidonis et al., 1993., Manfredini et al., 2020; Pavone, 1985; Shetty et al., 2010; Takeuchi et al., 2015; Wetselaar & Lobbezoo, 2016). Infected apical pathoses is especially vulnerable to ultra-forces, such as occlusal forces caused by bruxism, compared healthy periodontium or

non-infected apical pathoses. This situation may also affect the healing of the teeth with apical pathoses after root canal therapy (Harn et al., 2001). Furthermore, the force and effectiveness of chewing muscles also increase as a person grows older. Therefore, the probability of problems occurring increases (Torabinejad & Walton, 2011).

Bruxism is an important subject for dentistry, but dentists do not pay adequate attention to it. Because of poor understanding of bruxism, dentists sometimes focus on irreversible dental treatments, many of which might be unnecessary (Kleinberg, 1994). However, studies have suggested that psychosocial, physiological, biological, and exogenous factors may be effective against bruxism (Lobbezoo et al., 2017). Therefore, practitioners must continue to follow up-to-date literature about bruxism. This chapter has been aimed presenting new approaches to bruxism.

**Diagnosing bruxism**

An ideal method of diagnosing sleep and awake bruxism has not been fully established (Lobbezoo et al., 2017) because it is difficult to find an accurate, applicable, cost-effective, and accessible approach. Thus, more research should be done to solve this problem. Therefore, both patients and dentists should be careful about noticing bruxism and evaluating its signs and symptoms correctly (Lobbezoo et al., 2018).

**1. Non-instrumental approaches:** Non-instrumental approaches include self-reporting (e.g., questionnaires, interviews, history of bruxism, and patient complaints) and clinical inspection for two types of bruxism (Lobbezoo et al, 2018; Manfredini et al., 2020). In addition, contributions of the patient's bed-partner may be requested to evaluate grinding sounds related to sleep bruxism (Lobbezoo et al., 2018). However, 80% of bruxers do not produce grinding sounds and most patients are not aware that they are bruxers (Shetty et al., 2010). Furthermore, another problem of this approach is the patient's psychological state, which may affect self-reports. For instance, self-reporting might reflect distress rather than actual masticatory muscle activity. On the one hand, the self-reporting method is the most used method in dentistry clinics (Lobbezoo et al., 2018). On the other hand, only relying on a patient's complaints and symptoms may mislead the dentist to diagnose of bruxism.

Clinical inspection includes extraoral and intraoral examination of soft and hard tissues (Manfredini et al., 2020). These observations are important for diagnosing bruxism, but dentists' assessments should be done well not to be confused with other situations that cause the same problems. The possible reason for some negative clinical situations

should be considered before making a definitive diagnosis of bruxism. For example, occlusal wearing may be misleading for bruxism, because tooth wear can also be observed in people who do not gnash their teeth or have bruxism. Tooth wear may also occur due to functional activities or erosions (Grippo, 1991; Kaidonis, 2008; Lobbezoo et al., 2018).

**2. Instrumental approaches:** In this method, electromyographic recordings (EMG), polysomnographic recordings (recordings activity in the brain, heart, respiration system, and muscles in a sleep laboratory), a bruxcore bruxism-monitoring device etc. may be used (Lobbezoo et al., 2018; Manfredini et al., 2020; Shetty et al., 2010). They provide important reports about bruxism. Sometimes MRI (for muscle volume), spectroscopy and ultrasonography (evaluation of muscle thickness) can also be beneficial (Manfredini et al., 2020). EMG recording is frequently used in the evaluation of sleep bruxism. The most important advantage of EMG recording is that it does not use intraoral devices that may cause changing natural bruxism activity (Shetty et al., 2010). However, laboratory-based polysomnographic recordings are the criterion standard for diagnosis of sleep bruxism (Abe et al., 2012).

**Etiology of bruxism**

The factors that cause bruxism are debatable and many theories exist (Ella et al., 2017). One can conclude the etiology of bruxism is multifactorial, comprised of peripheral factors (e.g., occlusal harmony), biological factors (e.g., neurotransmission from the brain to masticatory muscle), and psychosocial factors (e.g., stress) (Bader & Lavigne, 2000; Feu et al., 2013). Etiologic differences also exist between awake bruxism and sleep bruxism (Cavallo et al., 2016).

When etiology of bruxism is investigated, first, peripheral factors could act as an agent. Occlusal interferences may be efficient on genesis of bruxism. Occlusal therapy is suggested as a treatment of this parafunctional disorder (Ramfjord, 1961; Safari et al., 2013). However, no clear correlation exists regarding the relationship between occlusion and the occurrence of bruxism (Klasser & Lavigne, 2015; Seligman et al., 1988). Furthermore, using occlusal therapy for bruxers who have healthy dentition is a controversial issue (Lavigne et al., 2008).

On the other hand, modern research methods have also improved the understanding of bruxism, because it can be easy to understand the mechanisms of physiological systems, including the cardiovascular, respiratory, central nervous, and musculature systems. Therefore, the mechanism of sleep bruxism may be also understood better (Klasser & Lavigne, 2015; Lavigne et al., 1996), because it is known that a relationship exists between sleep bruxism and transient sleep arousal,

which includes changes in cardiac and brain activities during sleep (Lavigne et al., 2007; Kato et al., 2003). Furthermore, the peripheral system also influences sleep bruxism, because it interferes with the sleep awake mechanism. Therefore, it can be said that central and peripheral systems affect oromandibular activity during sleep (Kato et al., 2003). Sleep bruxism has recently been considered a ‘‘sleep-related movement disorder’’ whose etiology and physiological processes are not fully understood (Klasser & Lavigne, 2015; Lavigne et al., 2008). In other words, sleep mechanisms affected by the chemicals of the brain and the necessity to maintain airway patency during sleep may increase the motor activity underlying sleep (Klasser & Lavigne, 2015).

Studies also suggest the dopaminergic system plays a role in the genesis of bruxism (Klasser & Lavigne, 2015; Lobbezoo et al., 1997; Winocur et al., 2003). Although short-term use of dopamine has been observed to reduce bruxism (Lobbezoo et al., 1997), in the long-term it has a negative effect on bruxism. Therefore, dose control should be used to reduce its side effects (Magee, 1970). However, using 1-3,4-dihydroxyphenylalanine (I-DOPA), which is the catecholamine (dopamine agonist) precursor showed the dropping effects bruxism (Klasser & Lavigne, 2015; Winocur et al., 2003). On the other hand, the effect of bromocriptine (another dopamine agonist) was not detected on sleep bruxism (Lavigne, et al., 2001). Some drugs related to dopaminergic, serotonergic, and adrenergic systems reportedly have effects on bruxism, however this issue is still unclear (Winocur et al., 2003).

When the researchers look at the other etiologic factors, psychosocial factors such as stress are considered relevant to awake bruxism’s etiology; however, the same significant correlation is not seen with sleep bruxism (Cavallo et al., 2016; Machado et al., 2020; Manfredini & Lobbezoo, 2009; Tavares et al., 2006). Yet, a systematic study of children and adolescents suggested different results. In this study, although the association between sleep bruxism and psychosocial factors in children younger than 5 was not clear, a significant relationship was observed between psychosocial factors and sleep bruxism in children and adolescents from 6 to 17 years old (de Luca Canto et al., 2015).

Studies have also shown bruxism may be genetic. A systematic analysis of 10 publications has given an opinion about the etiology of bruxism, which is partly genetic (Lobbezoo et al., 2014). Furthermore, in a study in which 349 adults and 151 children participated, the fact that a relationship exists between metalloproteinase 9 (*MMP-9*) and kateko-o-metiltransferaz (*COMT*) genes and bruxism for adults was proven by statistical analysis for the first time (Vieira et al., 2020). Another study

suggested that increases of *MMP-9* might be observed due to stress (Thaker et al., 2006). Therefore, it was suggested that *MMP-9* genetic variants, which combine with stressful situations, might predispose individuals to bruxism (Vieira et al., 2020). This etiologic factor is very new and needs more research.

However, a person is a living creature involving biopsychosocial properties (Myers, 2019). According to the biopsychosocial model, a person's biological (e.g., genes, bacteria, viruses, and structural defect), social (e.g., social norms of behavior, pressure from peers or parents, socioeconomic status), and psychological (e.g., stress, pain, affection, beliefs, and behaviors) conditions interact with each other and therefore determine whether the person is healthy or not. The psychology of a person affects his or her health directly (affecting the body directly) or indirectly (mostly behaviorally- e.g., smoking or alcohol consumption) with different ways (Ogden, 2019). Moreover, modern life involves constantly increasing stressful factors which negatively affect people's health. Developing social conditions also increases prevalence of bruxism (Wieckiewicz et al., 2014). Although the association between psychological factors and bruxism is not clear, psychological support is recommended for the management of bruxism (van der Meulen et al., 2000). Therefore, more attention should be paid to the association between bruxism and psychological conditions.

In addition, various risk factors affecting bruxism were also listed in a systematic review that included published literature from 2007 to 2016. Some of these factors are sleep apnea syndrome, smoking, drinking coffee or alcohol, emotional stress, and anxiety for adults. For children and adolescents, behavioral abnormalities and sleep disorders have also been predominant in addition to distress (Kuhn & Türp, 2018). Furthermore, a comprehensive review has suggested that awake bruxism is more common for people who have hyperkinetic movement disorders and syndromes combining stereotypies and cognitive impairment (e.g., Rett syndrome, Down syndrome, and autism spectrum disorders) (Ella et al., 2017).

Consequently, many issues concerning bruxism are still unclear and new studies are needed to clarify management of bruxism. Nevertheless, in understanding the etiology and risk factors of bruxism while taking a medical history from patients, it may be beneficial to take precautions and avoid possible problems due to bruxism. This is also important in point of making the patient conscious of behavior causing bruxism. It is especially important to be aware of the relationship between stress and bruxism. Because, if bruxism results from stress, psychological support should be sufficient to manage the condition. Therefore, irreversible

dental treatments will be unnecessary. In other words, dental practitioners should not forget that if necessary, consultation should be done with other branches and a multidisciplinary approach should be followed. In addition more studies should be done especially etiology of bruxism in order to choose the most effective treatment approaches. Also, using of the multidisciplinary approach in new studies should contribute the effective solution for this problem.

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# CHAPTER II

# A REVIEW OF IMMEDIATE LOADING PROTOCOLS IN IMPLANT-SUPPORTED FIXED PROSTHESIS

Asst. Prof. Dr. Emine Dilara ÇOLPAK

Alanya Alaaddin Keykubat University Faculty of Dentistry, Antalya, Turkey
e- mail: dilara.colpak@alanya.edu.tr, Orcıd ID: 0000-0002-5334-2421

## Introduction

## 1. Loading Protocols

Over the last 40 years, the placement of endosseous titanium dental implants has become a common treatment option in dentistry (Sommer, Zimmermann, Grize, & Stübinger, 2020).

Traditionally, it has been reported that a load-free healing period of 3 to 6 months is required to allow the implant to osseointegrate, develop a connective tissue interface between implant surface and bone, and minimize the risk of implant failures (Zhang, Wang, & Song, 2017). However, in patients, the acceptance of the treatment may be diminished due to reasons such as limited chewing function, suboptimal esthetics and restricted phonetic function, or the possibility of additional surgical procedures. Nowadays, different implant placement and loading protocols have been developed in response to the increasing demand for shortened treatment times (Esposito, Grusovin, Maghaireh, & Worthington, 2013; Gallucci, Hamilton, Zhou, Buser, & Chen, 2018; Morton et al., 2018).

Implant placement protocols were defined as follows:

a. Immediate implant placement: Dental implants are placed in the socket on the same day as tooth extraction.

b. Early implant placement: Dental implants are placed with soft tissue healing (4–8 weeks) or with partial bone healing (12–16 weeks) after tooth extraction.

c. Late implant placement: Dental implants are placed after complete bone healing, more than 6 months after tooth extraction.

Implant loading protocols were defined as follows:

a. Immediate loading: Dental implants are connected to a prosthesis in occlusion with the opposing arch within 1 week subsequent to implant placement.

b. Immediate restoration: Dental implants are connected to a prosthesis held out of occlusion with the opposing arch within 1 week subsequent to implant placement.

c. Early loading: Dental implants are connected to the prosthesis between 1 week and 2 months after implant placement.

d. Conventional loading: Dental implants are allowed a healing period of more than 2 months after implant placement with no connection of the prosthesis.

According to these definitions, implant placement and loading protocols can be made according to the following terms:

Type 1A: Immediate placement + immediate restoration/loading

Type 1B: Immediate placement + early loading

Type 1C: Immediate placement + conventional loading

Type 2A: Early placement with soft tissue healing + immediate restoration/loading

Type 2B: Early placement with soft tissue healing + early loading

Type 2C: Early placement with soft tissue healing + conventional loading

Type 3A: Early placement with partial bone healing + immediate restoration/loading

Type 3B: Early placement with partial bone healing + early loading

Type 3C: Early placement with partial bone healing + conventional loading

Type 4A: Late placement + immediate restoration/loading

Type 4B: Late placement + early loading

Type 4C: Late placement + conventional loading (Gallucci et al., 2018; Morton et al., 2018).

Factors such as the area where the implant will be placed (maxilla or mandible), the time of implant placement (immediately after extraction or after recovery), implant type and surface properties, primary stability and prosthetic restoration selection are the points to be considered in the immediate loading procedure (Bağrıvatan, Çelik, Çilingir, & Bayrakdar, 2015). Immediate loading protocol should be avoided in the presence of poor oral hygiene conditions, parafunctional habits, lack of primary stability or infection in the extraction area (Bağrıvatan et al., 2015; Bilhan, Sönmez, Mumcu, & Bilgin, 2009).

**2. Advantages of Immediate Loading Protocols**

Traditionally, in the implant placement procedure, the bone adapts around the implant during the healing phase. The bone will rebuild again

at the time the implant is exposed to biomechanical loading induced by occlusal forces. As a result of this biomechanical loading, increased bone loss will occur. Therefore, using the immediate loading protocol, the marginal bone is stimulated earlier by biomechanical loading without renewed bone remodelling after a few months (Sommer et al., 2020).

In the literature, high success rates have been reported in early (Fischer & Stenberg, 2004; Lai et al., 2008) or immediate loading results of implants, similar to conventional loading (Collaert, Wijnen, & De Bruyn, 2011; Maló, Nobre, & Lopes, 2013; Rocci et al., 2013). It has also been stated that the osseointegration process is unaffected by immediate loading of the implants, and low bone loss has proven to be one of the advantages of immediate loading (Donati, Botticelli, La Scala, Tomasi, & Berglundh, 2013; Zhang et al., 2017). In recent systematic reviews and meta-analyzes, the immediate loading protocol appears to be an acceptable alternative to the traditional loading protocol in terms of results. In addition, immediate loading with fixed prostheses is considered clinically successful in both the maxilla and mandible (Morton et al., 2018; Sommer et al., 2020).

From the patient's point of view; esthetics, comfort and satisfaction are improved due to the prostheses delivered immediately after implant placement. Moreover, with the advancing age of the patients, the frequency of a fixed prosthesis preference increases due to the decrease in the ability to adapt to removable partial dentures. From the dentist's point of view, immediate loading procedure is time-saving and beneficial from a financial viewpoint.

## 3. Immediate Loading for Single-Unit Implants

### 3.1 Clinical Outcomes

Implant-supported fixed prostheses are one of the most preferred restorations for single tooth deficiencies, and immediate restorations may not be important from an esthetic point of view in the load-carrying part of the dentition (De Bruyn, Raes, Östman, & Cosyn, 2014).

In the esthetic zone, a comprehensive assessment is crucial for the single-unit implant-supported restorations. Objective esthetic indices as a Pink Esthetic Score (PES) and White Esthetic Score (WES) are defined to evaulate clinical outcomes in the single-unit implant restorations (Belser et al., 2009). In the PES score, values such as the condition of the peri-implant tissues, mesial papilla, distal papilla, curvature of the facial mucosa, level of the facial mucosa are determined. In the WES score, the focus is on the visible part of the implant-supported restoration and restoration-related parameters such as general tooth shape, volume of clinical crown, surface texture, translucency and characterization are evaluated (Belser et al.,

2009). While reaching the final restoration, optimized PES/BES scores can be obtained with ideal soft tissue management and using the ideal material.

The peri-implant soft tissue management is the most important advantage in the single-unit implant restorations. It is reported that the provisional restorations used in the immediate loaded implants in anterior region can provide a satisfactory healing process (Belser et al., 2009). When considering the placement/loading protocols, there are factors that may limit the achievement of planned treatment. These factors can be listed as follows: A lack of primer stability, the need for advanced surgical procedures such as bone augmentation or graft, and patient-related factors (Morton et al., 2018).

### 3.2 Provisional Restorations

In the literature, it is found that provisional restorations allowed soft tissues to restore faster and more effective than healing caps in obtaining an emergence profile in peri-implant soft tissue. However, it has been reported that there is no difference between them in the formation of papillae (Martin, Pollini, & Morton, 2014). Provisional restorations can be performed at different times depending on the primary stability of the implant, the amount of space and/or defect between the implant and the bone, and the amount of soft/hard tissue graft.

Immediate loading followed by proper provisional restorations are highly beneficial in forming the gingival contour and interdental papilla by pushing the buccal margin towards the coronal side.

For provisional restoration; in the diagnostic cast model, the buccal part of the implant area is trimmed concave profile according to the adjacent gingival level and a provisional prosthesis is fabricated. The peri-implant gingival level is directed to the apical region with the help of the pressure created by the provisional restoration. Thus, interdental papilla formation and emergence profile are obtained. These contours are best achieved with screw-retained prosthesis. The emergence profile should be carefully transferred to the master model that will be used in the final restoration. Firstly, the provisional restoration is placed in the implant analog and the transition zone is captured with silicone impression material. After that, the provisional restoration is removed from the implant analog. The impression coping is placed to silicone material, and a flowable composite-resin or self-cure acrylic resin is injected around the impression coping (Figure 1). Thereby, the peri-implant soft tissue contours is transferred greatly to the laboratory (Figure 2). Besides, the impression can also be obtained via intraoral scanner much faster and more reliably (Cosyn, De Bruyn, & Cleymaet, 2013). In immediate provisional restorations, occlusal contacts should be avoided during centric and eccentric movement to

reduce the risk of early mechanical overload caused by functional or parafunctional forces (De Bruyn et al., 2014).

Fig. 1 The emergence profile of the provisional restoration was transferred to impression coping.

(ITI Treatment Guide, Volume 10, Chapter 6, Prosthetic Management for Optimal Esthetic Outcomes)

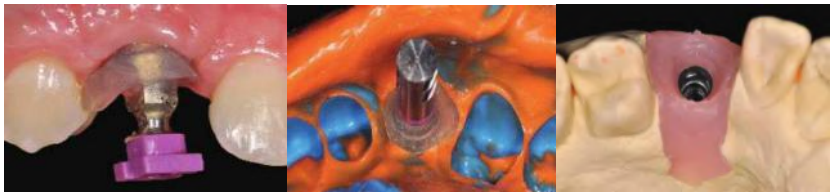

Fig. 2 A customized impression coping was transferred to final impression for fabrication of a master cast.

(ITI Treatment Guide, Volume 10, Chapter 6, Prosthetic Management for Optimal Esthetic Outcomes)

### 3.3 Complications

Apart from a biological impediment, abutment screw loosening and crown fractures have often been reported as complications in single-unit implant supported immediate restorations. The abutment screw loosening occured in <10% of cases initially attributed the fact that no torque device had been used. For this reason, it is generally recommended to the clinicians that abutment screws should be torqued up to 15-20 Ncm torque to limit screw loosening (De Bruyn et al., 2014).

On the other hand, it is reported that gingival recessions may occur as a result of the pressure of provisional restorations on the gingiva in immediately loaded implants. Also in single-unit immediate restorations, the lateral forces should be avoided (Bağrıvatan et al., 2015).

## 4. Immediate Loading for Partially Edentulous Patients

### 4.1 Clinical Outcomes

Predictable success rates for immediate loading have been reported in partially edentulous patients in terms of implant survival (95,5-100%) (De Bruyn et al., 2014). In the immediate loading for partially edentulous patients; factors such as the presence of extended edentulous space,

whether its involved in maxilla or mandible, the needs for bone grafting of the side should be taken into consideration. Also there are no data on soft-tissue parameters, esthetic outcomes or patient-related factors, and the available informations mainly focus on the load-carrying part of the dentition. In the literature, it has been stated that the splinted implant-supported restorations will reduce the occlusal load transfer to the implants compared with a situation with non-splinted implant units. In such situations, the lateral forces may be compansated (De Bruyn et al., 2014).

### 4.2 Provisional Restorations

In posterior region with regard to occlusion, very light centric occlusal contacts with no lateral contacts are proposed. The group function should be aimed for canine area. Light occlusal or non-occlusal contact is recommended in the anterior region that contacts are transferred to natural adjacent teeth as much as possible. Screw-retained provisionals can be prepared in the edentulous area in the anterior region help to recover the patient's esthetic function during the healing process (De Bruyn, Van de Velde, & Collaert, 2008; Schneider, Higginbottom, Weber, & Sones, 2002). Regular follow-ups are required to control for emergence profile, excess wear and to adjust the occlusal pattern whenever required. Additionally oral-hygiene habits are evaluated and improved.

### 4.3 Complications

One of the common complication is early implant loss in partially edentulous patients. Risk factors should be examined very carefully. Implant loss is usually associated with excessive load at the implant-bone interface during the healing process. Therefore, the over contacts should be eliminated whenever possible.

## 5. Immediate Loading for Totally Edentulous Patients

### 5.1 Clinical Outcomes

Immediate loading protocol for totally edentulous patients by means of a fixed implant-supported restorations is well-documented. In the mandible, when four or more implants are placed, the implant failure is reported 0–3.3%. Four to six implants in the maxilla give up to 7.2% failure rate, but this is reduced 3.3% as the number of implants increases (De Bruyn et al., 2014).

There are multifactorial parameters to be considered in the immediate loading protocol of complete edentulous jaws. These are as follows; the patient's general health conditions, peri-implant soft tissues, the presence of parafunctional habits, bone volume and bone density of the edentulous area, implant length and diameter, surface properties of the implant, implant shape, implant distribution in the edentulous region, and primary

stability. The treatment success depends on patient selection, pre-surgical planning and prosthetic quality (Morton et al., 2018).

### 5.2 Provisional Restorations

For complete edentulous patient, it has been recommended that the provisional restoration is delivered as soon as possible after surgery. Maximum oral hygiene and attention is needed to prevent complications during the initial healing phase.

Several immediate provisional restoration techniques have been recommended. One of them is; traditional acrylic complete dentures can be adjusted following the placement of the implant and converted into a screw-retained provisional restoration (Figure 3). Another option is fixed screw-retained temporary restorations can be prepared from full-arch acrylic resin immediately after implant placement (Figure 4).

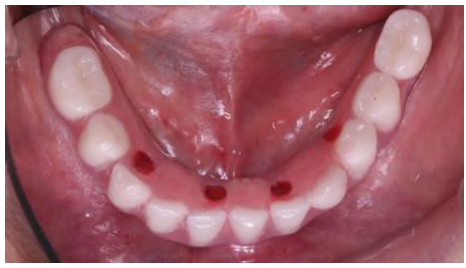

Fig. 3 Traditional complete dentures converted into a provisional restoration.

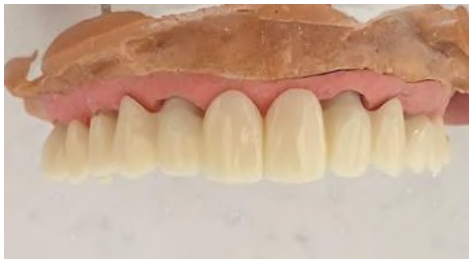

Fig. 4 Full-arch acrylic resin screw-retained provisional restoration.

The parameters such as support of facial tissues, phonetics, smile line and esthetic appearence were verified via provisional restorations. As a result, the temporary prosthesis provides an idea for appearance of the final restoration.

### 5.3 Complications

It is essential that the provisional restorations does not hinder soft-tissue healing, that the implants are rigidly splinted during the whole period of

provisionalization and that the prosthesis is in balance with the antagonistic teeth to enhance equilibrated loading on all the implants.

In a previous study, the incidence of the technical complications of implant-supported provisional restorations was evaluated. For 1011 implant-supported provisional restorations, it has been reported that 7.4% of the restorations have fractured within the first 4 weeks (Suarez-Feito et al., 2010). In the mandible, the absence of cantilever and the presence of a natural tooth in the antagonist arch reduce the possibility of complications. If there is an implant-supported restoration in the antagonist arch, the technical complication risk was 4.7 times higher (De Bruyn et al., 2014).

Acrylic resin-based provisional prostheses are tend to fracture, especially in the maxilla due to the distance between implants, and therefore they must be reinforced with rigid materials such as orthodontic wires (De Bruyn et al., 2014).

Also the occlusion should be checked in order to obtain uniform and well-distrubuted contacts with the opposite arch. If these contacts are not well-distributed, it may cause implant loss in the early stages of healing.

**Summary**

Immediate loading protocols can be considered a change of conception in implant dentistry because it is believed that an unloaded period was essential to allow bone healing in order to contribute osseointegration. In progress of time, this belief has been replaced by different loading protocols. It has been approved that different factors such as the primary stability of the implant play a role in the success of osseointegration.

High patient satisfaction is the most substantial advantage of immediate loading, especially during the early healing phase. Immediate loading can be affected positively on the quality of life. Recent studies have reported that immediate loading protocol improves the quality of life of patients. In addition, provisional restorations, which are delivered immediately after the implants are placed, allow the gingiva to heal quickly, and the emergence profile can be created remarkably.

Consequently, better esthetic results are gained with immediate and early loading compared to conventional loading, and the patient satisfaction is also higher. However, scientific and clinical risk assessment should be performed for each case, and conventional methods should be considered in patients whom immediate loading is not suitable.

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# CHAPTER III

# AN OVERVIEW OF ALL-ON-FOUR CONCEPT-A LITERATURE REVIEW

Asst. Prof. Dr. Gülfeşan ÇANAKÇI*& Dr Dt Emel KURU**

Trakya University Faculty of Dentistry Department of Mouth, Tooth And Jaw Surgery, Edirne, Turkey
e mail: gulfesancanakci@gmail.com, Orcid ID:0000-0001-7553-7062

Republic of Turkey Ministry of Health Bornova Oral and Dental Health Center, Izmir, Turkey
e mail: dtemelkirac@gmail.com, Orcid ID: 0000-0001-9720-0823

## Introduction

Severe atrophy of the alveolar ridge usually occurs after tooth loss in the edentulous jaw with increasing severity over time. There are several prosthetic treatment options available for this particular situation; total dentures, removable implant-supported prostheses or fixed implant-supported prostheses (Att, 2009). Among all these options, implant-supported fixed prostheses have been stated to increase patient satisfaction (Att, 2003; Patzelt, 2014). However, both alveolar atrophy and increased maxillary sinus volume after posterior maxillary teeth loss restrict implant placement in the posterior region (Asawa, 2015; Att, 2003). In such cases, pterygoid and zygomatic implants can be placed with bone grafts (Asawa, 2015) with the disadvantages of prolonged surgical operation time, deterioration of patient comfort and the increase of surgical complications (Agliardi, 2008; Graves, 2011). Posterior implant therapy is disadvantageous in patients with a resorbed mandible and mandibular nerve located above the alveolar crest (Gravesi 2011; Krekmanov, 2000; Patzelt, 2014). Nerve repositioning, grafting, short and/or angled implant placement also have surgical and patient-related disadvantages (Asawa, 2015; Att, 2003; Graves, 2011; Maló, 2003). In order to avoid such disadvantages, placing tilted implants were recommended (Asawa, 2015). The technique is called as the All-on-four technique and firstly used by Malo *et al*. in 2003 and in the atrophic full arch mandibular and maxilla in 2005 (Maló, 2003; Maló, 2005).

The principle of the All-on-four concept is to use four implants at anterior maxilla in edentulous patients to support temporary, fixed and immediate prostheses (Bevilacqua, 2011; Krekmanov, 2000). While the two implants are placed axially, two posterior implants are placed distally at an angle to reduce the length of the quill and allow up to 12 teeth to be applied to the prosthesis (Maló, 2003, 2005; Menini, 2012). The permanent prosthesis to be made on these implants can be fixed or removable.

The purpose of this literature review is to evaluate the effectiveness and long-term success of the All-on-four treatment concept.

**Materials and Methods**

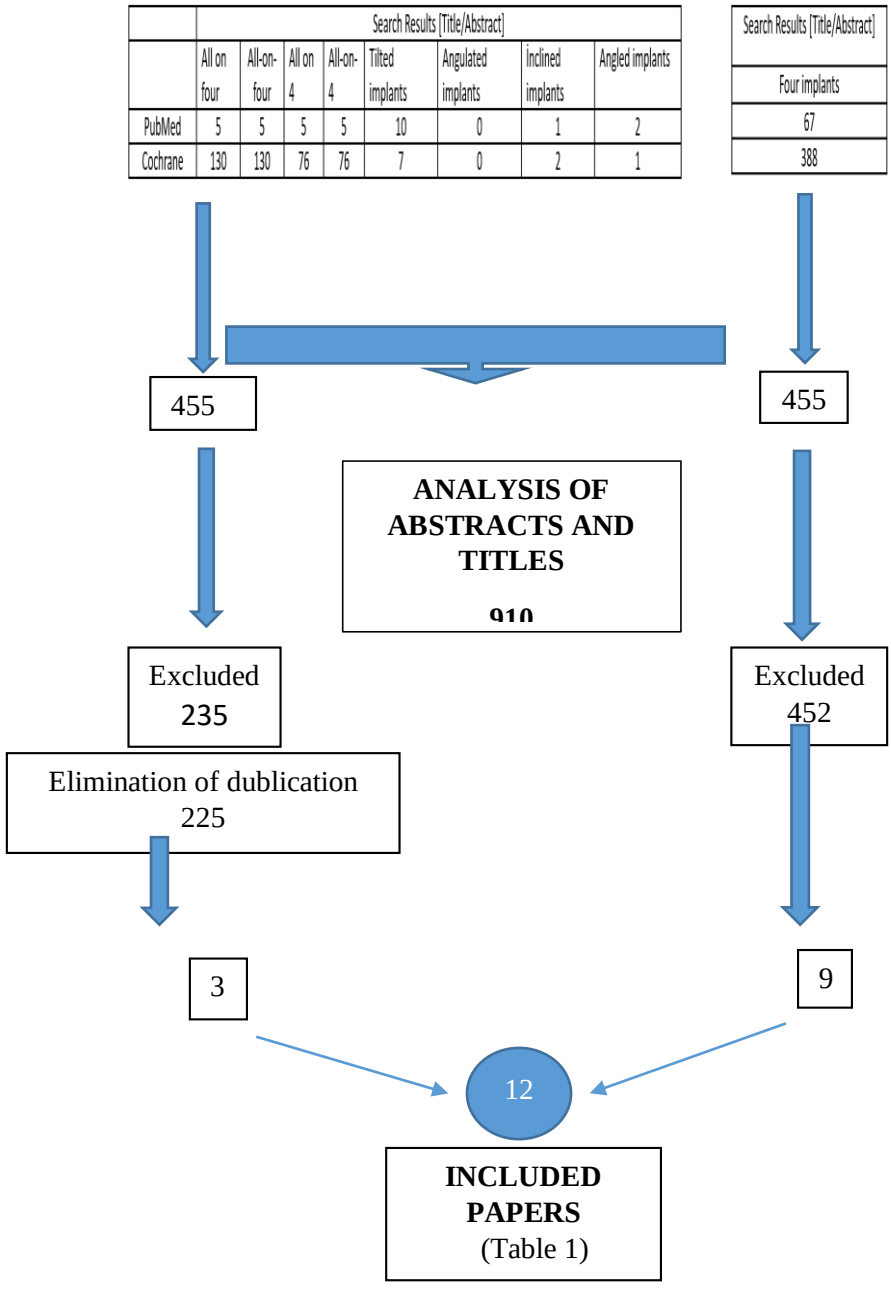
Literature search was performed using the electronic bibliographic database MEDLINE (user interface: pubmed.gov; http://www.ncbi.nlm.nih.gov/pubmed/) and a web-based search engine for Cochrane, while searching (in title and / or abstract) keywords "all on four, all-on-four, all on 4, all-on-4, tilted implants, angled implants, angulated implants, inclined implants" and "four implants". Among the studies, only clinical trials with one year or more follow-up were included. The exclusion criteria were defined as; case reports, systematic reviews, biomechanical studies, finite element analysis, studies involving more than four implants, zygomatic implants, oblique distal implants, or additional implants supporting temporary or final prosthesis (Figure 1).

The abstracts of the articles were preliminarily examined by 3 researchers. Later, full texts of qualified articles were examined and evaluated according to the inclusion criteria. Full texts were supposed to be in English.

Clinical trials with a minimum 1-year follow-up period were evaluated and the survival rates of the implants and prostheses, marginal bone loss, prosthetic and surgical complications and patient satisfaction levels were recorded.

For each study included, the following data were collected using a specially designed data abstraction form: author names, year of publication, study design, jaw(s) examined, number of implants, survival rates of implants, survival rates of prostheses, prosthetic material, and reported complications.

**Figure 1. Search strategy; total number of researches, excluded and included studies.**



## Results and Discussion

A total of 910 articles were examined. As a result of Pubmed and Cochrane review, 135 article for "all on four" [Title / Abstract], 135 article for "all-on-four" [Title / Abstract], 81 article for "all on 4" [Title / Abstract], 81 article for "all-on-4" [Title / Abstract], 17 article for "tilted implants" [Title / Abstract], 3 article for "angled implants" [Title / Abstract], 0 article for "angulated implants" [Title / Abstract], 3 article for "inclined implants" [Title / Abstract] and 455 article for "four implants" [Title / Abstract] were found (Figure 1). All articles were eliminated, except for studies that were clinical trials and followed for one year or more (Figure 1). After the full texts of all the remaining articles were examined by 3 researchers, 12 articles were included in the compilation (Table 1).

**Table 1.Characteristics and main outcomes of the included studies**

| Study | No of Pat/I | Follow-Up Period | Survival Rates I/P | Jaw | Compl. | P Material |
|---|---|---|---|---|---|---|
| Gherlone 2016-Prospective | 25/120 | 1 Year | 100 | Max + Mand | No | Co-Cr Alloy |
| Krennmair 2014-Prospective | 24/96 | 2 Years | 100/100 | Mand | Mech | Resin Veneered with Metal Framed |
| Francetti 2008-Prospective | 62/248 | 1 Year | 100/100 | Mand | Mech | Procera® System |
| Francetti 2012-Prospective | 47/196 | 3 Years | 100 | Max + Mand | Mech | Procera® System |
| Tallarico 2016-Randomized Controlled Trial | 40/200 | 5 Years | 95 | Max + Mand | Bio + Mech | Ti-Zr framed + resin material |

| | | | | | | |
|---|---|---|---|---|---|---|
| Cannizzaro 2017- Randomized Controlled Trial | 60/180 | 3 Years | 100 | Mand | Bio + Mech | Metal Resin Retained |
| Cannizzaro 2013- Randomized Controlled Trial | 60/180 | 1 Year | 100 | Mand | Bio + Mech | Metal Resin Retained |
| Weinstein 2010 Prospective | 20/80 | 1 Year | 100 | Mand | No | Procera® System |
| Elsyad 2019 Prospective | 36/144 | 1 Year | 98,6/100 | Mand | No | Ceramo-Metal Fixed |
| Grandi 2012- Clinical Trial | 47/ 188 | 18 Months | 100 | Mand | No | Metal Framed Fixed |
| Krennmair 2016- Prospective | 41/164 | 3 Years | 100 | Mand | Bio + Mech | Co-Cr Framed Fixed |
| Pera 2017- Clinical Trial | 76/333 | 22 Months | Test: 100<br><br>Control: 93.9 | Max | Bio | Test: Carbon Fiber-Framed<br><br>Control: Pd Alloy Framed |

** Pat (Patient), I (Implant), P (Prosthesis)

***Implant Survival Rate***

The All-on-Four treatment concept is an attempt to address some goals such as experienced surgical and restorative team, careful patient selection, short treatment intervals and reduction of surgical procedures by providing a relatively simple, predictable treatment option for the edentulous patients (Durkan, 2019). According to the results of most of the follow-up studies, implant survival rates are 100 % (Cannizzaro, 2017; Cannizzaro, 2013; ELsyad, 2019; Francetti, 2008; Francetti, 2012; Gherlone, 2016; Grandi, 2012; Krennmair, 2014; Krennmair, 2016; Weinstein, 2012).

Tallorico *et al.* compared the success of All-on-Four and All-on-Six techniques after 5 years of follow up (Tallarico, 2016). According to the results seven implants failed at the 5-year follow-up examination: six in the All-on-Six group (5%) and one in the All-on-Four group (1.25%), with no statistically significant differences.

Pera *et al*. evaluated the carbon fibre versus metal framework in full-arch immediate loading rehabilitations of the maxilla with four to six implants (tilted ones were in distal area) (Pera, 2017). They found a similar implant survival rate of 100 % in carbon fibre group and 93.9 % in metal framework group.

***Marginal Bone Resorption***

After 12 months of follow-up, Gherlone *et al*. reported that peri-implant bone loss in restorations prepared by the conventional impression method was 1.08 ± 0.77 mm in parallel implants and 1.09 ± 0.32 mm in distal inclined implants (Gherlone, 2016). They reported the peri-implant bone loss in the restorations prepared by digital method as 1.13 ± 0.66 mm in parallel implants and 1.06 ± 0.91 mm in distal inclined implants. There was no statistically significant difference between bone losses after 6 and 12 months of follow-up, and they did not find a statistically significant difference in prostheses made after digital and conventional impression measurements.

In a follow-up study in 2 years by Krenmair *et al.*, peri-implant marginal bone level after 12 and 24 months were reported as -0.18 ± 0.20 mm and -0.40 ± 0.29 mm for all implants (Krennmair, 2014). Also bone level differences of 0.35 mm between implants placed in healed and fresh extraction sites at the 1st year and the 2nd year measurement.

Francetti *et al*. reported that the peri-implant bone loss after 1-year follow-up was 0.7 ± 0.4mm and 0.7 ± 0.5 mm for axial and tilted implants without a significant difference (Francetti, 2008).

In a prospective clinical study, Francetti *et al*. reported that the marginal bone loss for axial and tilted implants 1.15 ± 0.61 and 0.81 ± 0.53 in the

mandible and 0.85± 0.74 and 0.85± 0.34 in the maxilla at 3 years follow-up (Francetti, 2012).

In a study that compared the 5-year clinical and radiological outcomes of patients rehabilitated with four or six implants, Tallarico *et al*. reported a marginal bone loss in the All-on-Four groups as 1.71 ± 0.42 (1.45–1.83) (Tallarico, 2016).

Grandi *et al*. measured peri-implant bone levels of immediately placed implants according to All-on-Four concept at 6-12-18 months (Grandi, 2012). Peri-implant bone levels were 0.31 ± 0.12 mm after 6 months, 0.58 ± 0.112 mm after 12 months and 0.7 ± 0.107 mm after 18 months, without a significant difference.

Weinstein *et al.* reported that the marginal bone loss around immediate loaded axial and tilted implants was 0.6 ± 0.3mm and 0.7 ± 0.4 mm, and no significant difference between tilted and axial implants (Weinstein, 2012).

Elsyad *et al.* showed that there was no difference in bone resorption between anterior and posterior implants in All-on-Four concept prosthetic rehabilitation of edentulous mandibles (ELsyad, 2019).

At the 1, 2 and 3-year evaluations, Krennmair *et al.* reported the marginal bone resorption was 1.11 ± 0.4 mm, 1.26 ± 0.42 mm, and 1.40 ± 0.41 mm. So, statistically significant effect of time for marginal bone reduction were reported (Krennmair, 2016).

Pera *et al*. reported a statistically significant difference between test and control groups comparing the amount of bone resorption around the implants. A greater peri-implant bone resorption was found in the metal framework group (mean: 1±0 mm) than the carbon fibre group (mean: 0.8 mm) (Pera, 2017).

Cannizzaro *et al*. compared All-on-Four and All-on-Two concepts in a 3-year randomized clinical trial. Marginal bone loss between groups was statistically significant; in average 1.70 mm in All-on-2 group and 1.56 mm in All-on-Four group (Cannizzaro, 2013).

***Prosthetic material***

In a 12-month follow-up study by Gherlone *et al*., screwed cobalt-chrome restorations were used as permanent restorations (Gherlone, 2016).

Weinstein *et al*. used Procera® system as permanent restorations in their study involving 20 patients with severely atrophic mandibles (Weinstein, 2012). Krennmeir *et al*. used resin veneered prosthesis with metal framework as permanent prosthetic material in their studies which they applied All-on-Four concept implants that were immediately placed in the healed socket (Krennmair, 2014).

Tallarico *et al*. used titanium-zirconia frameworks and resin material as permanent restorations in their study that compared All-on-Four and All-on-Six immediately loaded implants (Tallarico, 2016).

Cannizzaro *et al*. used metal-resin screw retained cross-arch prostheses in the All-on-Four and All-on-Two groups, and in 18 months and 3 years follow-up (Cannizzaro, 2017; 2013).

Elsyad *et al*. used ceramo-metal fixed prostheses over All-on-Four implants (Elsyad, 2019).

Krennmair *et al*. used cobalt-chromium framework fixed prostheses in their prospective study with a 3-year follow-up (Krennmair, 2016).

Pera *et al*. used carbon fiber-framed prostheses in the test group and metal-framed prostheses (palladium alloy) in the control group as permanent prosthetic material (Pera, 2017).

***Biological/Mechanical Complications***

In the study by Krenmair *et al*., it was reported that while 5 patients had temporary fractures, a total of 15 acrylic teeth in 10 patients permanent prosthesis had to be replaced/renewed and 18 patients prosthesis needed to be rebased (Krennmair, 2014).

Francetti *et al*. reported a light temporary hipoesthesia on the left side of the lower lip after surgery in one case, acrylic prosthesis fracture in 7 cases (11 %) and no definitive prostesis fracture (Francetti, 2008).

At another prospective clinical study, Francetti *et al*. reported a fracture of the acrylic prosthesis for 5 cases (15 %) in the mandible, 3 cases (19 %) in the maxilla, and a fracture of the final mandibular framework for one case after 3 years follow up (3 %) (Francetti, 2012).

Tallarico *et al*. reported one failed implant and no failed prostheses at the 5-year follow-up in the All-on-Four group. Also they said that the All-on-Four treatment concept showed higher risk of complications during the entire follow-up period than All-on-6 treatment concept (Tallarico, 2016).

In the study of Cannizzaro *et al*., 25 post-operative complications were observed, 12 in All-on-Two and 13 in All-on-Four groups. Biological complications were observed only in All-on-Four group. As biological complication; soft tissue hypertrophy was seen in two implants. Although mechanical complications include metal framework incompatibility, need for occlusal correction, loss of abutment screw, fracture / rupture of resin teeth, fracture in distal extension framework, fracture in connecting screw were seen in both groups, there were no statistically significant difference (Cannizzaro, 2017).

In the study conducted by Grandi *et al.*, although a fracture was observed in one of the patients temporary prosthesis, no complications were encountered in their permanent restorations (Grandi, 2012).

Elsyad *et al*. reported 2 implants fail by surgical complications and no provisional or definitive prostheses fracture (Elsyad, 2019).

Krennmair *et al*. reported that the most common mechanical complication was discoloration of the prostheses requiring professional cleaning. Also the other mechanical complications were resin teeth fractures, technical in-office teeth renewing as a result of abrasion/fracture and basal relining/reduction. The biological complications as mucositis, gingival hyperplasia, fistula, recessions were determined in both axial and tilted groups (Krennmair, 2016).

In their study, Pera *et al*. reported 10 implants fail as a biological complication in the metal framework group, while there were no prosthetic complication (Pera, 2017).

***Patient Satisfaction***

Krenmair *et al*. reported that the patient satisfaction rate was high in their study (Krennmair, 2014). In a prospective study, Weinstein *et al*. evaluated the patient satisfaction in eighteen cases. After one year follow up, aesthetic satisfaction was considered as excellent or very good by 66.7 %, and phonetics and mastication were considered excellent or very good by 77.8 % and 88.9 %. They defined that there was a high degree of acceptance for their treatment (Weinstein, 2012).

**Conclusion**

The all-on-Four treatment concept seems to be an alternative treatment for edentulous jaws according to the common demand of a cost-effective treatment concept, decreased treatment times with a lower patient morbidity, and a higher patient quality of life as compared with extended surgical approaches, respectively. A careful patient selection and an experienced surgical and restorative team are essential for successful treatment outcomes. Nevertheless, there is a lack of sufficient long-term data with follow ups of at least 5 years. Long-term clinical controlled studies are needed.

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# CHAPTER IV

# IMPLANT SUPPORTED MANDIBULAR OVERDENTURE ATTACHMENTS

Asst. Prof. Dr. İkbal LEBLEBICIOĞLU KURTULUŞ

Erciyes University Faculty of Dentistry, Department of Prosthodontics, Kayseri, Turkey
e-mail: ikbal_leblebicioglu@hotmail.com, Orcid ID: 0000-0001-9122-9852

Overdentures supported by two implants to treat mandibular edentation offers more economic and acceptable results for the patient by enhancing patient comfort, providing adequate support, contributing to retention, and decreasing the number of implants required to fix the prosthesis (Kurtulus, 2018). This indication covers the majority of elderly patients who have lost their teeth in their advanced age. In addition, mandibular overdentures may benefit elderly patients who have been using complete dentures for years, have lost their motor skills and think that they cannot use the complete denture for a longer period of time. These problems are more common in the mandible (Kern, 2016; Carlsson, 2014; Stoumpis, 2011; Al-Harbi, 2018).

Even in advanced atrophy, standard surgical implant procedures for implant overdentures can be applied. However, reduced treatment practices in elderly patients, such as placing only two implants, will also reduce the risk to the patient and tissue (Mericke-Stern, 2000). With such an approach, the age of the patient is no longer seen as a contraindication.

In the light of the above studies, mandibular overdentures are a real alternative to fixed prostheses in terms of economical and time saving (Mericke-Stern, 2000).

Prosthetic care in overdentures with mandibular 2 implants, depends on the attachment system used; however, the long term clinical research about attachment systems is limited (Mackie, 2011).

## Overdenture Attachments

Prosthesis retention is defined as resistance to vertical and oblique stresses or as resistance to movement in the opposite direction of the path of insertion (Researches, 2005).

Mechanical precision attachments applied on roots of teeth; that increase the retention and stabilization of overdentures, have been used for years.

It is difficult to ensure the retention of the dentures in conventional complete dentures. With the development of implants, a wide variety of complete denture treatments and better retention have been provided. For

the long-term success of implants and overdenture, clinicians should consider the intermediate elements between the overdenture and the implant in their treatment options (Svetlize, 2004)). Determination of the attachment system, suitable for implant supported overdenture cases, is the one of the most complex issues for dentists. These attachment systems should both have sufficient retention properties to increase the stability of the prosthesis and allow the prosthesis to be easily attached and removed by the patient (Uludag, 2012).

Currently, there are a large number of attachment options available with different attachment characteristics (Trakas, 2006). Learning the mechanical properties of the existing attachment systems and their force distribution properties during loading, is the best method to decide which attachment system to use. The most suitable attachments may exhibit different levels of flexibility depending on the situation. The flexibility of the attachment is related to the movement in a predetermined direction or directions between the abutment and the overdenture. When chewing forces are applied to the overdenture, the force is shared between the implants and the mucosa supporting the prosthesis base (Sadowsky, 2000). The rate at which this sharing occurs depends on the type of the attachment and the displacement of the mucosa (Heckmann, 2001).

The attachments used in overdentures supported with a minimum number of implants are exposed to more stress and wear, as they require more soft tissue support. When the number of attachment increases, the fulcrum movement in the single axis decreases and thus the retention increases at the same rate.

Considerations in the selection of attachment;

- Oral hygiene,
- Anatomical conditions (lower-upper jaw difference, opposed arch dentition, interocclusal distance etc.)
- The distance between the implants,
- The age of the patient (muscle function),
- The amount of restraint need,
- Biomechanical factors,
- Pain in the soft tissue,
- The patient's psychological condition and expectations,
- The social status of the patient,
- Economic conditions,

- The number of supporting implants and their distribution in the crest,
- Bone height,
- The form of the alveolar crest and the amount of resorption should be considered (Trakas, 2006; Wismeyer, 1995; Menucucci, 1998; Pasciuta, 2005).

The retention forces seem to be effective on the long-term success of the overdenture and patient satisfaction. Many attachment systems have holding forces around 20 N. It is accepted that forces of 20 N will be sufficient for overdentures in the edentulous mandible (Walmsley, 2002). However, attachment forces have been specified in a wide range of restraint between 3-85 N (Trakas, 2006; Walmsley, 2002).

Ideally, an attachment should provide the ability to control the degree of retention.

**Types of The Attachments**

1. Bar attachments
2. Stud attachments
3. Ball attachments
4. Telescopic copings
5. Magnetic attachments

**1.Bar Attachments**

Bar attachments are units that connect two or more implants' infrastructures. Connecting the implants provides more durability (Ichikawa, 1996). This system consists of a prefabricated or individually prepared custom cast bar that connects the implants to each other and clips placed inside the overdenture (Ichikawa, 1996) (Figure 1).

In alveolar crests with advanced atrophy, especially against horizontal forces, the best stabilization is provided by bar or parallel-walled telescopes (Uludag, 2012).

**Figure 1.** Bar attachment (Retentive systems for implant-borne hybrid dentures, Basic Information, 2018)

Although the retention and stability of the bar connections are quite good, gingival problems may be encountered under the bar when there is not enough distance between the gums. In cases where implants are placed inclined to the lingual because of anatomical reasons, the bar may have to be placed towards to the lingual. This causes an increase in the bucco-lingual width of the prosthesis in this area. This result may cause phonetic complications and aesthetic problems (Ichikawa, 1996). Bar retaining systems are indicated in upper jaw prostheses, in the presence of an excessively resorbed crest in the lower jaw, oval crests, in cases where partial resorption of bone and / or soft tissue is performed, and in prostheses where high retention and stability are desired (Misch, 2004). It is contraindicated in non-resorbed crests with insufficient interocclusal distance, inadequate economic status of the patient (need for more implants) and in cases where oral hygiene is thought to be poor (Misch, 2004). While it is accepted as advantageous for affecting the retention and stability positively, their disadvantages are that they are not economical and the construction stages are complex (Misch 2004, Uludag, 2010).

It is necessary to have at least 4 implants for the use of bar as an attachment system in the upper jaw with implant-supported overdentures, and at least 2 implants for the use of bar as an attachment system for implant-supported overdenture in the lower jaw (Sadowsky, 2000). The fabricated bar may or may not have a cantilever extension. However, studies have reported that distal cantilever extensions have a positive effect on the stability of the implant-supported overdentures and that can be placed further than the first premolar area (Asvanud, 2004). There are 2 attachment types available in bar connections; rigid and flexible grippers. There are contradictions in the literature regarding the use of rigid or flexible (resilient) connections in bar attachments (Mericske-Stern, 2000).

## 2.Stud Attachments

Stud attachments have been available in the dental implant market for many years as they provide acceptable retention and stabilization of implant overdentures and are easy to apply (Kurtulus, 2018; Trakas, 2006).

In cases where the interocclusal distance does not allow the placement of ball attachment systems, stud attachments can be used (Lee, 2006).

Stud attachment systems are systems that are compatible with almost all implants such as Locator® (Zest Anchors Inc), Positioner (Dentium Co.), Zaag (Zest Anchors Inc), Preat (Zest Anchors Inc), ERA (Sterngold Inc) (Geçkili, 2010). Locator® attachments, one of the most frequently used stud attachment systems in today's dentistry, provide hinge and vertical flexibility (Geçkili, 2010). Among the attachments used, Locator® attachment is an attachment system that requires the least distance (maximum 2.5 mm). This attachment system can compensate for divergence of about 40 degrees (20 degrees per implant) (Geçkili, 2010).

The retaining nylon matrix of Locator® can be used when the divergent angle between two implants is up to 20 °. There are pink, blue and transparent colored options with varying degrees of retention (Restoring Straumann Implants With Locator® Abutments, 2012) (Figure 2).

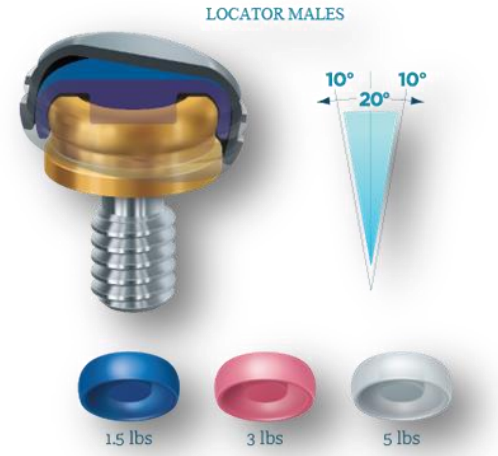


**Figure 2**. Locator® and matrices (Restoring Straumann Implants With Locator® Abutments, 2012).

In cases where the divergence between two implants is 20 ° -40 °, there are 4 different retention nylon matrixes (Restoring Straumann Implants With Locator® Abutments, 2012) (Figure 3).


**Figure 3.** Locator® extended range attachments (Restoring Straumann Implants, 2012).

ERA retainers are also classified as resilient retainers that can be applied to almost all implant systems (Landa, 2001).

When using more than one stud attachments, it is important that the attachments are parallel to each other. In addition, the attachments should match the path of insertion (Geçkili, 2010; Misch, 2004)

**3.Ball Attachments**

It is the simplest type of attachment for implant-supported overdentures. The ball attachment system mainly consists of a donut-shaped nylon insert, the metal part in which the nylon insert is located, and the metal post with a certain resemblance to which this nylon insert sits (Misch, 2004).

In addition, gold or titanium matrices protected by metal housings instead of O ring plastic caps have been developed on ball attachment connections (Misch, 2004). It is a system that is widely used in almost all systems in implant-supported overdentures (Misch, 2004).

Ball attachments can be used if the distance between implants is too much or too little, the interocclusal distance is not sufficient to place a bar, the arc is V-shaped and the patient's economic level is not sufficient (Özkan, 2012).

In addition to ease of application, implant-supported overdentures with ball attachments have advantages such as ease of use by the patient, low cost, different retention degrees, and the ease of fabrication (Özkan, 2012; Misch, 2004). However, since the ball attachments produced until today do not have an anti-rotation system, loosening problems are frequently encountered during chewing functions (Misch, 2004).

Its disadvantages include the loss of restraint observed over time, the fact that it is not preferred as a maxillary attachment, and contraindication in patients with limited interocclusal distance (minimum 3.1 mm matrix height) (Sadowsky, 2000).

**4.Telescopic Copings**

The telescopic approach has gained importance in implant supported overdentures. The use of telescopic attachments in implant-supported overdentures started in 1989. Primary crowns are prepared on the implant abutments, and in non-parallel implants, the contours can be modified with a milling device, thus providing a suitable entrance path to the overdenture can be achieved (Heckmann, 2004). Overdentures with telescopic attachments are widely used in prosthetic dentistry due to their versatility and long-term success (Heckmann, 2004). The low inclination differences of the supporting implants are compensated by the contours of the primary structure of the telescopic attachments, and the secondary

structure is located in the overdenture (Geçkili, 2010; Heckmann, 2004). Heckmann et al (Heckmann, 2004) reported that they achieved positive results clinically and radiographically, after 10 years with 2 implant-supported telescopic retained overdentures in 23 patients.

### 5.Magnetic Attachments

Magnet-retained connections are used in prosthetic dentures, maxillofacial prostheses, complete or partial prostheses, and implant-supported prostheses overdentures in dentistry (Ai, 2004). Magnetic attachments provide an alternative retention mechanism for implant supported overdentures. Magnetic attachments have two components: the magnetic part remaining in the overdenture and the part on the implant abutment (Ai, 2004).

Magnet-retained prostheses can be applied independently of the path of insertion of the overdenture. Due to these properties, magnetic attachment systems can be used alone or with other types of attachment systems. Tokuhisa et al (Tokuhisa, 2003) stated that due to the feature of the prosthesis allowing movement in all directions (universal flexibility), lateral force transmission to the natural tooth or implant is very low in magnet-retained prostheses. When compared with ball and bar attachment systems, the retention and patient satisfaction values of magnetic systems were found to be less (Ai, 2004; Tokuhisa, 2003). However, magnetic attachments are preferred in cases where the patient's age is older and muscle function is insufficient.

### Conclusion

In implant supported overdentures, the connection between the implant and the overdenture is provided by an attachment system. The structure, shape, holding capacity and flexibility (resilience) of the attachment systems vary according to each other. Many studies are carried out considering in what type of cases, which attachment system should be used in order to achieve a higher success rate. However there is no scientific evidence that any attachment system is superior to another.

In order to make optimal abutment selection decision, the clinician should consider the patients expectations, patients age, interocclusal distance and implant angulation.

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# CHAPTER V

# SINGLE TOOTH IMPLANT TREATMENT IN THE ANTERIOR ZONE AND AESTHETICS

Asst. Prof. Dr. İkbal LEBLEBICIOĞLU KURTULUŞ

Erciyes University Faculty of Dentistry, Department of Prosthodontics, Kayseri, Turkey

e-mail: ikbal_leblebicioglu@hotmail.com, Orcid ID: 0000-0001-9122-9852

Patients show an emotional reaction when they lose a tooth in the maxillary anterior region (Namal, 2001). They have no doubts about the necessity of replacing this tooth, and the economic aspect of the business is also insignificant (Misch, 2004, Kan, 2001). In the treatment of anterior single tooth deficiency, single tooth implant replacement treatment is increasing in demand due to increased awareness of the predictable aesthetics provided by single tooth implant restoration (Misch, 2004; Scalar, 2004; Testori, 2018).

The products including the surface of the implant body and created with the developed technology have significantly increased the success of osseointegration (Misch, 2004). Advances in abutment connection and prosthetic reconstruction of implants make it possible to mimic the aesthetics and function of a natural tooth (Scalar, 2004, Phillips, 1998). Reconstruction of the form and function of a single tooth, including the papillae and facial gingiva, is more predictable than that of multiple adjacent teeth (Kois, 2001).

The papillae are supported by the bony height and soft tissue attachment of the neighboring natural tooth (Kois, 2001; Buser, 2007). If this is ideal, the aesthetic results are based on more controllable issues (Wheeler, 2007). Acceptable treatment results, including aesthetics, can be achieved for anterior single tooth placement in areas without tissue deficiency, because tissue support is provided by neighboring teeth in single tooth deficiencies in the anterior region (Buser, 2017).

Rapid loss of bone volume occurs during the first few months after extraction. This event results in soft tissue loss with 3 to 4 mm vertical and horizontal bone loss in the first 4-6 months (Buser, 2017; Atwood, 1971, Testori, 2018). In more dramatic cases, bone loss is so much that it is not possible to place the implants without initial grafting (Testori, 2018).

In recent years, guided bone regeneration techniques, that are very successful in supporting the implant in function and orienting the hard tissue required for soft tissue architecture in the field, have been developed. At the Implant Dentistry Conference in August 2006, after an

extensive review of the literature, Dr Moy and Aghaloo reported a 95.5% survival rate for 1232 implants placed with guided bone regeneration techniques over a 12-72 month period (Consensus proceedings, 2006). Allowing 4 to 6 months for the grafts to heal prior to implant placement in the aesthetic zone where implant position and angulation can be critical will result in ideal implant positioning on a stable bony base (Wheeler, 2007).

**Dimensional Positioning Of The Implant**

Placing the implant in the correct position in 3 dimensions is one of the most important keys to obtain aesthetic treatment result regardless of the implant system used (Testori, 2018). The correct 3D position depends on the planned restoration that the implant will support (Buser, 2007). The relationship between the implant and the recommended restoration position should depend on the position of the implant shoulder. Because this position will affect the hard and soft tissue response last (Buser, 2017).

The position of the implant shoulder can be viewed in 3 dimensions;

1.Mesiodistal

2.Orofacial

3.Chronoapical

When planning the ideal 3D implant position, a distinction is made between ideal and dangerous areas in each dimension (Wheeler, 2007).

Aesthetic complications such as peri-implant bone resorption followed by soft tissue recession can occur if the implant shoulders are placed between dangerous areas (Wheeler, 2007; Testori, 2018).

**1. Mesiodistal Dimension**

Dangerous areas of mesiodistal dimension are located close to the adjacent root surface. This danger zone is 1.0-1.5 mm wide. (Figure 1 and Figure 2) Placing the implant shoulder too close to the adjacent tooth may cause resorption of the interproximal alveolar crest at the implant level (Wheeler, 2007).

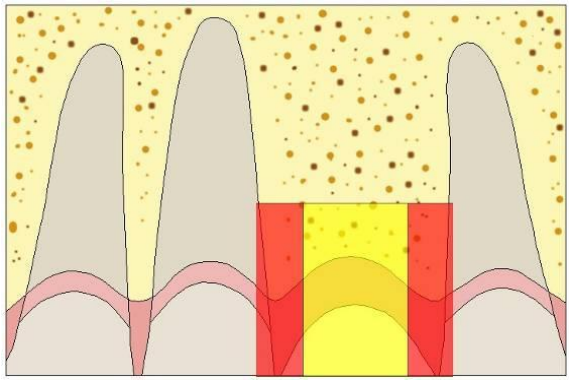

Figure 1. Correct implant position in mesiodistal ideal area (yellow) (Chappuis, 2017)

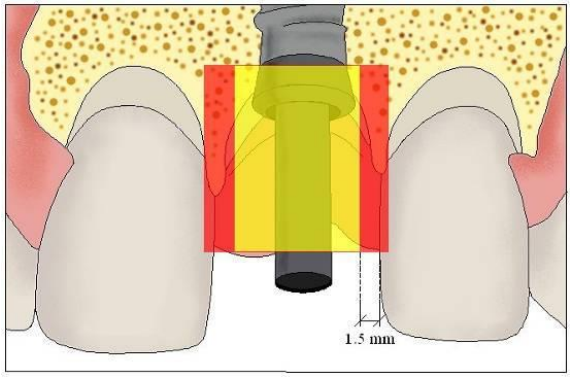


Figure 2. Diagram showing the ideal area and danger areas in mesiodistal direction (Chappuis, 2017).

**2.Orofacial Dimension**

The ideal area is approximately 1.5-2 mm wide when measured from the ideal emergence profile. Dangerous areas coincide with the facial and palatinal part of the ideal area. (Figure 3)

Implant placement in the facial danger area can result in a potential risk of soft tissue recession due to the obvious reduction of the facial bone wall (Wheeler, 2007).

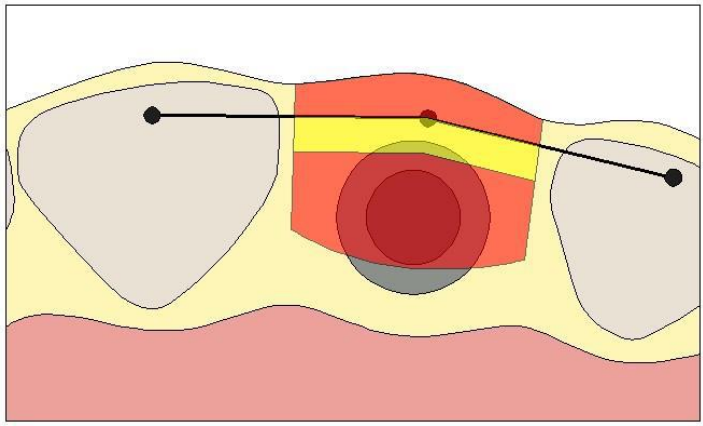

Figure 3. Schematic representation of orofacially ideal and dangerous areas (Chappuis, 2017).

**3.Chronoapical Dimension**

The ideal area in the chronoapical dimension is a narrow band of approximately 1 mm. Ideally, the neck of the implant should be positioned 1 mm apical to the enamel-cementum border of the contralateral tooth (Wheeler, 2007). (Figure 4)

If it is placed in lower or higher dangerous areas, it may cause undesired facial bone loss and successive gingival recession.

Ideally, the implant shoulder is placed approximately 2 mm apical of the midfacial gingival margin of the implant restoration. (Figure 5)

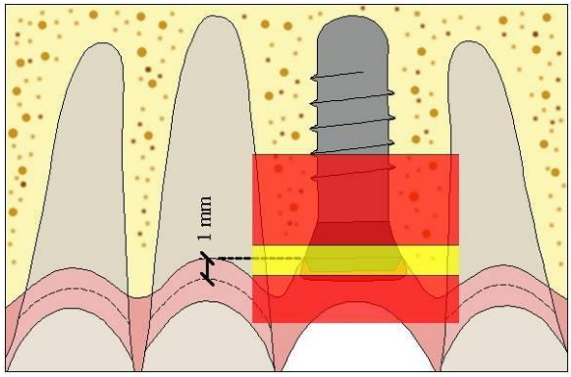


Figure 4. Chronoapical ideal and dangerous areas (Chappuis, 2017).

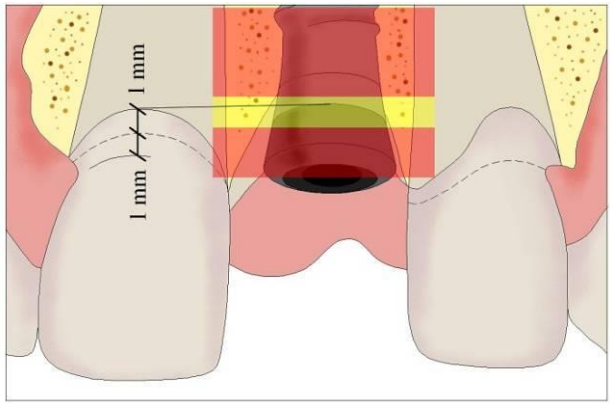


Figure 5. Chronoapical ideal and dangerous areas (Chappuis, 2017).

## PROSTHETIC CONSIDERATIONS FOR ANTERIOR MAXILLARY SINGLE TOOTH IMPLANT AESTHETICS

Adequate horizontal and vertical bone volume is important for long-term aesthetic soft tissue stability (Wheeler, 2000). Appropriate hard and / or soft tissue augmentation procedures are required in case of deficiencies and losses. Soft tissue management process begins, after the bone has enough quantity and quality (Wheeler, 2000; Vogel, 1999).

The use of soft tissue healing in prosthetic guidance to improve aesthetic results in implant therapy enables early introduction of prosthetic components that match the cross-sectional anatomy of the lost tooth or the planned aesthetic placement at the gingival level. These components support and guide soft tissue healing, following many surgical procedures, and have a tremendous impact on the final soft tissue architecture provided in the implant area (Roccuzzo, 2018; Tarnow, 2005).

### *Custom Abutments and Temporary Restorations*

Immediate placement of custom abutments and temporary restorations on the exposed portion of submerged implants is a method that can be used for early initiation of soft tissue healing for improved aesthetic soft tissue contours (Roccuzzo, 2018; Pirker, 2009; Holst, 2005). During implant placement, the surgeon must create a surgical index in the dental laboratory to prepare a study model for abutment and temporary restoration (Block, 2004, Scalar, 2004).

### Custom Healing Abutments

Another prosthetic technique used by the surgeon to initiate the guidance of early soft tissue healing is the special tooth-shaped healing

abutments. These anatomically shaped healing abutments reflect approximately similar cross-sectional anatomy of the lost tooth or the planned location at the gingival level. Because each anterior maxillary tooth is unique, prefabricated components provide ideal results in terms of tissue support and directed soft tissue healing (Roccuzzo, 2018; Block, 2004; Scalar, 2004).

***Use of Temporary Restorations***

It is always desirable to maintain or recreate the harmonious gingival and bony architecture around dental implants. Temporary restorations can be used to shape and stabilize peri-implant soft tissues during the healing phase and after 2-phase surgery (Holst, 2005; Délben, 2012). The use of temporary restorations with an adequate emergence profile to optimize aesthetic treatment outcomes is recommended to guide and shape the peri-implant tissue before final restoration (Délben, 2012).

In addition, such temporaries allow assessment of aesthetic parameters before the end of treatment and provide comfort and psychological advantages for the patient (Holst, 2005; Délben, 2012). In addition, temporary crowns have important diagnostics in peri-implant soft tissue aesthetics as well as the ideal shape of the final crown. Therefore, it is highly recommended to use temporary crowns in aesthetic areas. The use of the temporary crown at 6 to 8 weeks creates the final soft tissue contour (Buser, 2007).

In cases of immediate loading or after second phase surgery, peri-implant soft tissues are subject to recession. These recessions occur during the first 3 months after surgery. Therefore, proper timing is essential for predictable results and success. Many authors agree that the natural appearance of an implant-supported crown can only be achieved by the formation of the appropriate emergence profile (Délben, 2012).

Removable partial dentures offer cost and time-efficient solutions for the placement of the lost tooth, but their use in the anterior maxilla may not provide optimal aesthetic results as they may not support soft tissues properly. In addition, the prosthesis is attached and removed from the mouth and its movement during function can irritate the underlying tissues. Resin-bonded temporary restorations can provide better comfort for the patient and provide appropriate support of the surrounding soft tissues (Block, 2004). These can be easily transferred to screw retained temporaries,after osseointegration of the implant to contour the peri-implant gingival architecture and shape the natural emergence profile. Maturation and stabilization of the peri-implant mucosa around the temporary crown, takes place in the first 3-12 months. When the desired shape and emergence profile is provided, the impression is taken for the main model and final crown fabrication (Block, 2004, Délben, 2012,

Buser, 2007). The use of the temporary crown is very important in the following situations;

1. If the patient has high expectations for the aesthetic treatment result
2. If the patient has a thin, high scallop gingival biotype
3. If additional diagnostics is required depending on the shape or position of the planned reconstruction (Buser, 2007).

***Selection of Implant Abutment***

Abutment design and material for single anterior implants must meet the following requirements (Holst, 2005). Inaccurate fit of matched components prevents screw loosening during function (Byrne, 1998). Other factors are long-term stability, biocompatibility and aesthetics. There are many types of abutments available for the aesthetic zone. Initially, abutments for single-tooth implants had one standard design (Holst, 2005). Cast abutments exhibit insufficient sensitivity in matching the corrosive phenomenon and the mating parts (Abrahamsson, 1998). As a result, prefabricated titanium abutments were introduced. As an alternative to commonly used titanium abutments and to meet increasing aesthetic demands, all-ceramic components were introduced to the market in 1993 (Rasperini, 1998).

***Abutment Material***

Many studies have demonstrated the successful application of ceramic and titanium abutments with respect to soft tissue and marginal bone stability (Holst, 2005). Abrahamsson et al. investigated different abutment materials and their effects on the soft tissue barriers surrounding dental implants (Abrahamsson, 1998). They showed that the height and quality of soft tissues are affected by the abutment material. While gold alloy and metal-ceramic abutments caused soft tissue shrinkage and increased crestal bone resorption, titanium and ceramic abutments caused mucosal attachment formation (Abrahamsson, 1998). Rasperini et al. and Rimondini et al. also reported the similar findings (Rasperini, 1998; Rimondini, 2002).

The use of all-ceramic components and restorations is increasing, although the fracture resistance of metal-ceramic crowns cemented on titanium abutments is higher. Ceramic abutments have excellent aesthetic potential and biocompatibility as well as long-term stability (Hanawa, 2020). The first all-ceramic abutments were made of fully sintered aluminum oxide ($Al_2O_3$) ceramic, and only one size was available on the market. Custom preparations of these abutments took time and involved the risk of microcrack formation during preparation and placement that could result in fracture. Nowadays, the ceramic material option for

abutment manufacturing is zirconium oxide ceramic. Yttria stabilized zirconium oxide (Y-TZP-zirconium oxide, tetragonal zirconia polycrystals stabilized with yttria) is a highly biocompatible ceramic material and exhibits break-resistant properties (Hanawa, 2020; Piconi, 1999; Kucey, 2000).

Rimondini et al. showed that zirconia ceramic surfaces cause less bacterial accumulation than commercial pure titanium (Rimondini, 2002).

## Aesthetic Complications and Causes

The aesthetic complications in implant-supported restorations can be caused by both iatrogenic and anatomical factors such as bone or soft tissue deficiencies. Aesthetic complications in many patients are combination of many factors. A clear understanding of these factors is very important in terms of improving the results of aesthetic treatment in daily practice (Buser, 2007; Buser, 2017).

### *Iatrogenic Causes of Aesthetic Complications*

- Unsuitable, wide-sized implant (wide platform) selection
- Chronoapical, mesiodistal or orofacial malposed implant placed in a dangerous area
- A surgical approach that causes excessive stress on the healing capacity of tissues by causing resorption of the facial bone wall.
- The use of temporary restorations that are not suitable for shaping peri-implant soft tissues or not using temporary restorations at all.
- Improper use of restorative implant components or materials for restoration (Buser, 2007; Buser, 2017).

### *Anatomic Causes of Aesthetic Complications*

- Horizontal or vertical bone deficiencies in the implant area
- Vertical bone deficiencies in adjacent root surfaces
- Implant areas in multiple tooth losses causing the placement of neighboring implants (Buser, 2007; Buser, 2017).

## Conclusion

In single tooth implant treatments, improper implant selection using wide-platform implants, improper implant positioning by entering one or more hazard areas, or using an inappropriate treatment approach that places excessive stress on the biological healing capacity of peri-implant hard or soft tissues can cause aesthetic complications. These iatrogenic factors may be combined with anatomical risk factors such as horizontal or vertical bone insufficiency. These aesthetic implant complications or errors can sometimes lead to bone or soft tissue failure, necessitating removal of the implant. Even if there are no complications, placing the implant in the ideal 3D position and soft tissue management is very

important in order to obtain a good emergence profile in the anterior region.

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# CHATER VI

# ANKAFERD BLOOD STOPPER USAGE AREAS IN DENTISTRY AND PERIODONTOLOGY

Asst. Prof. Mehmet GÜL

Department of Periodontology, Faculty of Dentistry, Harran University, Sanliurfa, Turkey,
e-mail:m.gul3838@gmail.com, Orcid ID: 0000-0002-5721-8778

## The Content of Ankaferd Blood Stopper (ABS)

Ankaferd Blood Stopper (ABS) is the first medicinal plant extract used as a hemostatic agent in Turkish medicine. ABS is produced by standardizing extracts from plants and obtaining a mixture from them: 8 g *Vitis vinifera* (Vine), 7 g *Alpinia officinarum* (Galangal), 5 g *Thymus vulgaris* (Thyme), 7 g *Glycrrhiza glabra* (Licorice) and 6 g of *Urtica dioica* (Nettle) in 100 ml extract. ABS has been proven as a result of various studies that each herb in this herbal mixture has an effect on vascular endothelium, blood cells, angiogenesis, cell proliferation and various mediators (Goker et al. 2008, Kaya et al.2013, Haznedaroglu et al. 2010, Odabaş et al. 2013, Işler et al. 2010).

*Thymus vulgaris* (Thyme) prevents oxidative damage, lipid peroxidation and associated atherosclerosis with its antioxidant properties (Lee et al. 2007). ABS has been proven that the extract obtained from the roots of *Glycrrhiza glabra* (Licorice) has antiangiogenic effects in vitro and reduces the formation of VEGF. In addition, this herb has been found to have anti-inflammatory, antioxidant, antithrombotic, and antiateriosclerotic effects (Sheela et al. 2006). *Vitis vinifera* (Vine) has antiatherosclerotic and antitumoral effects (Barka et al. 2000). *Alpinia officinarum* (Galangal) has been found to inhibit nitrik oksit (NO) production in mouse peritoneal macrophage activated by lipopolysaccharide. The plant is known to have antispasmotic and antibacterial properties (Matsuda et al. 2006). *Urtica dioica* (Nettle) creates an endothelium-derived hypotensive response in the rat, which may be due to the NO secretion from the endothelium and vasodilation that occurs after the opening of potassium channels (Testai et al. 2002). These plants in ABS content perform tissue oxygenation and physiological hemostatic process without disturbing the effect of any coagulation factor (Seymen 2013). The hemostatic effect of ABS has been reported to occur as a result of blood proteins, especially fibrinogen, and erythrocytes forming a "protein network" in plasma and serum (Işler et al. 2010).

## The Mechanism Action of Ankaferd Blood Stopper

Ankaferd Blood Stopper (ABS) are anti-bleeding preparations. They enable the formation of a network of structures in plasma and serum in a short time. As a result of the analysis has been reported that this network of structures (hemostatic and biochemical) is formed by the interaction of Ankaferd Blood Stopper with the proteins existing in the blood and especially with fibrinogen, and it provides the formation of vital aggregation of red cells. In this case, it is thought to be related to protein erythrocyte interaction for blood stopping at the level that will provide tissue repair. Blood cells have also been reported to accompany this network. In the Ankaferd Blood Stopper network, the physiological hemostatic process acts independently of the tissue factor-related blood coagulation structure, without disturbing this system. Therefore, Ankaferd Blood Stopper has been reported to be effective both in individuals with normal hemostatic values and individuals with defective primary or secondary hemostasis. "Ankaferd Blood Stopper" can be safely chosen as an auxiliary product for the clinic to stop intense external bleeding, including mucosal cracks. Particular care should be taken not to place Ankaferd Blood Stopper intravenously or into the blood circulation system (Kaya et al. 2013, Haznedaroglu et al. 2010, Seymen 2013).

ABS-induced protein network formation is linked to the functions of blood proteins (erythrocytes and platelets) and red blood cells and is thought to affect the entire physiological hemostatic process. In the biochemical measurements made, it was observed that it was not effective on coagulation factors. It has been shown that ABS application can be an effective method both in individuals with normal hemostatic parameters and in patients with disseminated intravascular coagulation and hemophilia, which cause lack of any factor or hemostasis. After the use of Ankaferd, has been reported that there is a decrease in plasma fibrinogen activity and the amount of fibrinogen, and therefore a prolongation of thrombin time. ABS; Once approved for use in external hemorrhage and dental bleeding by the Turkish Ministry of Health, to prevent excessive bleeding may occur in the case of dental procedures in Turkey and added to the protocols that can be used to treat (Seymen 2013).

## The Background of Ankaferd Blood Stopper in the Literature

ABS is an effective hemostatic agent with a potential therapeutic effect that can be used in the treatment of bleeding. In the process of stopping bleeding, continues according to protein agglutination. ABS plays a role in the formation of an encapsulated protein network to allow erythrocyte aggregation in the injured vascular region. ABS interacts with fibrinogen and blood proteins. The protein network structure formed by ABS does not affect any coagulation factors and plays a role in the entire physiological

hemostatic process. In studies conducted, no adverse effects were observed after ABS application of coagulation factors factor II, V, VII, VIII, IX, X, XI and XIII levels. This has shown us that ABS can be used safely even in patients with disseminated intravascular coagulation, insufficient primary hemostasis and / or secondary hemostasis ( Uçar et al. 2008, Cipil et al. 2009, Aydin 2009 ). In a study conducted in rabbits, Bilgili et al applied ABS orally and investigated the acute mucosal toxicity, hematotoxicity, hepatotoxicity, nephrotoxicity and biochemical toxicity. As a result of the study, they concluded that ABS application did not have any negative effects. During the study, they suggested that ABS had no signs of toxicity (Bilgili et al. 2010). In the literature, no side effects occurred or reported as a result of the use of ABS have been reported ( Kurt et al. 2008: 262, Kurt et al. 2008:2156-8, Ibis et al. 2008 ).

ABS leads to the rapid formation of a specific hemostatic protein network together with erythrocyte aggregation in the injured vascular area. The effectiveness of ABS in lower gastrointestinal bleeding has been investigated, but there is not much information on this subject except for the case report. In addition, ABS has been applied to reduce adverse conditions in upper gastrointestinal bleeding (Kurt et al. 2008:2156-8), arterial bleeding, which is especially vital in the digestive system (Kurt et al. 2008: 262), and bleeding due to solitary rectal ulcer (Ibis et al. 2008). In another study, ABS was applied to tonsillectomy patients. In this study, the effectiveness of ABS application as a hemostatic agent during an operation was evaluated (Teker et al. 2009). In a study, it was emphasized that tonsillectomy had a great cost. Tonsillectomy surgery took a long time and they reported that ABS shortened the operation time. They stated that ABS reduced the operation time by 8 minutes in total. Considering the low cost of procurement, they emphasized that its use is beneficial (Teker et al. 2009). In addition, they stated that it is beneficial to be preferred by surgeons considering the ease of use as well as the reduction of the operation cost. The low cost of ABS also facilitates its routine use. However, was stated that this cost-effectiveness should be evaluated in detail by further research (Teker et al. 2009).

ABS is a standardized herbal extract derived from plants. It has been emphasized in previous studies that the herbs used in ABS have antibacterial effects. In a study, *U. dioica* was reported to be a plant with antibacterial action against *Streptococcus pyogenes*, *Staphylococcus aureus* and *Staphylococcus epidermidis*. (Janssen and Scheffer 1985). In addition, Fisgin et al. (2009) tested ABS on infected wounds and evaluated its activity on wounds. Positive opinions have been reported that it has antibacterial properties against bacteria and that it may reduce the need for postoperative prophylaxis (Teker et al. 2009).

In a study, the effects of ABS were evaluated by applying Necrotizing enterocolitis (NEC) to an experimental neonatal rat model. In the findings obtained as a result of the study, it has been reported that ABS increases antioxidant activity and decreases oxidative stress. As a result, it has been suggested that it reduces DNA and protein oxidation and lipid peroxidation. The low levels of TNF-α and IL-1β resulting from ABS application inform us that it is associated with significant improvement in histopathological findings and decreased apoptosis. As a result, they suggested that ABS protects against gut damage due to its antioxidant and anti-inflammatory properties. In the study, it was emphasized that anti-inflammatory effects decreased (decreased TNF-α and IL-6 levels) and anti-apoptotic effects occurred (decreased number of positive cells for caspase-3, -8 and -9 and caspase) after ABS treatment. It showed us that ABS has antioxidant properties, increased TAS, GSH and SOD levels and decreased TOS and OSI. Additionally, reductions in lipid hydroperoxide, AOPP and 8-OHdG, which are lipid, protein and DNA oxidation products, are other evidence indicating the antioxidant properties of ABS. As a result, ABS has been reported to have a protective effect against intestinal damage in an experimental neonatal rat NEC model due to its powerful antioxidant, anti-inflammatory and antiapoptotic properties. ABS may be a new and effective treatment option for the prevention and treatment of NEC. More studies are needed to determine its effect on the development and prognosis of NEC in premature babies (Buyuktiryaki et al. 2019).

In a study conducted by Gül *et al.* (2020), They created 4mm diameter defects in the palatal regions of rats and evaluated the effects of ABS on mucosal wound healing. As a result of histological and immunohistochemical analyzes and western blot analysis, they emphasized that ABS positively affected mucosal wound healing. This situation has informed us that the use of abs on wounds in the oral mucosa has positive effects. They reported that this positive effect was related to the antibacterial, antioxidant and anti-inflammatory properties of the herbal extracts contained in ABS (Gül et al. 2020). In a study, it was reported that ABS had a positive effect on wound healing and new bone formation process (Tek et al. 2014). İşler et al. (2010) reported that infection, inflammation and necrosis occured less in early bone healing as a result of ABS application, and that more new bone formation was observed in the defect formed in the ABS applied group. In a study conducted by Tanik et al., the scores of the groups were compared histologically, and inflammatory cell infiltration, vascular dilatation and bleeding rates were examined in non-diabetic rats on day 28. In the cases examined, it was reported that there was a significant decrease in the group in which ABS was applied compared to the control group (Tanik et al. 2018). In a study, the effects of ABS on bone healing were investigated and it was reported that ABS accelerated early bone healing and did not

cause any foreign body reaction as a result of histopathological examination (Şimşek et al. 2013). In a study, the effects of ABS and a heterologous bone graft on bone healing were investigated. The magnification rates resulting from the application of the bone graft to the sinus floor were evaluated. As a result of the comparison made in the 1st week, there was no evidence that a new bone formation occurred in any group. In the other weeks, it was emphasized that there was an increase in new bone formation in all groups and a maximum increase was reported in the ABS + heterogreft group (Cakir et al. 2015). In a study, the histological scores of the rats on the 28th day were examined and although there was no statistically significant difference between the ABS and β-TCP (β-tricalcium phosphate ) + ABS groups, new bone formation was reported to be higher in β-TCP + ABS compared to the control group. It has also been reported to be consistent with the impact of β-TCP on day 56. It has been reported that there is a significant difference in bone healing between the β -TCP + ABS group and the control group (Tanik et al. 2018).

## Conclusion

As a result, since ABS is a herbal product, its negative effect on human health is limited. It has been reported that ABS has antimicrobial, antibacterial antioxidant and anti-inflammatory properties, as shown by its researches. Dentistry and especially periodontal surgery, bleeding is one of the conditions that negatively affect during surgery. The time spent to control bleeding both prolongs the duration of the operation and affects the comfort of the patient negatively. In addition, ABS increases the success rate of the surgery thanks to the positive effects of the wound surfaces that occur after surgery on the healing process. Likewise, an important issue in periodontal surgery is the formation of new bone. It is thought that ABS can contribute to periodontal surgery by positively affecting new bone formation. The use of ABS in periodontal surgery will be beneficial due to its low cost and positive properties. For more information about ABS, more research should be done and its positive or negative properties should be investigated.

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## CHAPTER VII

# CURRENT APPROACHES OF DEVITAL BLEACHING

Neslihan Büşra Keskin, DDS, PhD[*] & Selen İnce Yusufoğlu DDS, PhD[**]

[*]Department of Endodontics, Faculty of Dentistry, Yıldırım Beyazıt University, Ankara, Turkey
e mail: ozerolbkeskin@gmail.com, Orcid ID: 0000-0002-1053-7675

**[*]Department of Endodontics, Faculty of Dentistry, Yıldırım Beyazıt University, Ankara, Turkey
e mail:dtselenince@hotmail.com, Orcid ID: 0000-0002-7826-6023

### Causes of Tooth Discoloration

Considering the importance of the anterior teeth in terms of general appearance, disorders such as color and shape disorders may show poor aesthetics and cause psychological and social problems for people (Ngan, Fields 1995). Discoloration of anterior teeth is a cosmetic problem, is often a result of traumatic injury and that needs to be corrected (Goldstein, Garber 1995). Tooth discoloration differs in terms of etiology, appearance, location, severity, and proximity to tooth structure (Dahl, Pallesen 2003). Accurate diagnosis of the cause of tooth discoloration is of great importance, since it has a profound effect on the outcome of treatment (Watts, Addy 2001). It can be classified as internal, external or a combination of both depending on its location and etiology (Hattab et al 1999).

### The Causes of External/Internal Discoloration

### External Discoloration Causes

The main causes of external discoloration are chromogens derived from habitual intake of dietary sources, especially drinks such as wine, coffee, tea and chocolate or tobacco, mouthwashes and plaque on the surface of the teeth (Watts & Addy, 2001).

### Internal Discoloration Causes

### Systemic internal causes:

- **Genetic:** Amelogenesis imperfecta, dentinogenesis imperfecta, congenital erythropoietic porphyria, erytroblasthosis fetalis, hyperbilirubinemia
- **Drug-related:** Tetracycline
- **Disease-related:** High fever during the tooth formation, Vitamin d, c deficiency
- **Metabolic:** Dystrophic calcification, fluorosis

**Local internal causes:**

- **Pulpal hemorrage:** It is the most common cause of discoloration after trauma. The blood enters the dentin tubules and then decomposes. Blood destruction products, especially iron sulfides, can enter dentine tubules and cause discoloration in dentin (Arens 1989). Initially, a temporary color change of the crown to pink may be observed. This is followed by hemolysis of red blood cells. The released hemoglobin then joins with the decaying pulpal tissue to form iron (Watts & Addy 2001, Guldener 1993). Iron, in turn, can be converted into dark iron sulfates with hydrogen sulfates produced by bacteria and turn the color into gray. These products can penetrate deeply into the dentinal tubules and cause discoloration of the entire tooth.

- **Pulp necrosis:** Bacterial, mechanical, or chemical destruction of the pulp causes tissue necrosis, which can lead to the release of harmful by-products that can penetrate the tubules and change the surrounding dentin color (Attin et a 2003). The degree of discoloration is directly related to pulp necrosis. The longer the necrotic tissues remain in the pulp chamber, the greater the color change (Rostein 2002).

- **Pulp tissue remnants**: Pulp residues that remain in the pulp chamber, especially in the pulp horns, cause gradual discoloration (Faunce, 1983).

- **Restorative materials**: Due to the dark metallic components in the structure of amalgam, it has the effect of converting the color of dentin to dark gray. In addition, discoloration occurs due to leakage in composites (Rostein 2002). Metal pins and prefabricated posts are sometimes used for the restoration of anterior teeth. Post cores and pins that are not placed properly can reflect under the tooth or composite because of their metallic structure (Rostein 2002).

- **Endodontic materials:** Phenol or iodoform-based intra-canal medicaments penetrate into the dentinal tubules by oxidation. These components tend to gradually discolor the dentin. Even calcium hydroxide can lead to discoloration of the dentin during retreatment procedure (Tınaz et al 2008). Root canal sealer, especially those containing metal (eg silver), cause dark discoloration in the tooth if they are not completely removed from the pulp chamber and access cavity (For example; AH26 (Dentsply De Trey, Konstanz, Germany), Epiphany (SybronEndo, Orange, CA), mineral trioxide aggregate (MTA), triple antibiotic pastes (metronidazole, minocycline, and ciprofloxacin))(Davis et al 2002, Kim et al 2000). Although the MTA has excellent biocompatibility (Ribeiro et al. 2005, Ribeiro et al. 2006), this gray material causes undesired tooth discoloration in the aesthetic region of the dentition (Bortoluzzi et al 2007). Even with

white MTA, it is assumed that discoloration occurs due to iron oxidation process (tetracalcium aluminum ferrite).

- Irrigation solutions may also cause discoloration depending on the destructive effect of sodium hypochlorite (NaOCl) on erythrocytes and its ability to crystallize on the dentin surface, it can distort the dentin color. Neutral and insoluble brown-precipitate may be solid precipitates that block the dentine tubules form a barrier between the sealer and the dentin surface, and increase coronal microleakage, and these by-products may be toxic to periapical tissues. Para-chloraniline (PCA) as a result of contact with NaOCl and Chlorhexidine (CHX). This precipitate causes discoloration in crown (Basrani et al 2007). To prevent this reaction MTAD (a mixture of a tetracycline isomer, citric acid and a detergent; Dentsply Tulsa Dental, Tulsa, OK) can make brown coloration due to doxycycline release (Tay et al 2006).

- **Calcific Metamorphosis:** Following traumatic injuries, excessive irregular dentin formation may be observed in the pulp chamber. In such cases, there may be temporary loss of blood supply (nutrition), which continues with the destruction of odontoblasts. As a result of the gradual decrease of the translucency of the crowns of such teeth, yellowish or yellow-brown coloration is observed. Anterior teeth are more affected. Root canal treatment is usually required. Then intracoronal bleaching is applied.

- **Root resorption:** Although clinically asymptomatic root resorption, may show a pink appearance (pink spot) on the cervical (Watts, Addy 2001).

- **Aging:** As the tooth age, due to thinning of the enamel and the accumulation of dentin over time, physiologically optical color change occurs in the crown and acquires a darker color. Due to cracks and other changes in the enamel surface, the cumulative (proliferating) coloration effect of food and beverages becomes more evident in elderly patients (Watts, Addy 2001).

**Bleaching Agents**

The bleaching agents such as hydrogen peroxide, carbamide peroxide, and sodium perborate are oxidizing or reducing agents.

Hydrogen peroxide is the active ingredient of currently used tooth whitening materials. It can be applied directly or produced by chemical reaction from carbamide peroxide (Budavari et al 1989) or sodium perborate (Hagg 1969). Peroxides can be classified as organic and inorganic. They are strong oxidizers and can be considered as hydrogen peroxide products. Hydrogen peroxide is used in dentistry as a whitening material in different concentrations ranging from 5% to 35%. When used

in high concentration, hydrogen peroxide can burn tissues in contact and release free radicals. Solutions with high concentrations should be used with caution because they are thermodynamically unstable and can burst unless kept in the refrigerator and in a dark container. Due to its low molecular weight, this substance can penetrate into dentin and release oxygen that breaks the double bonds of organic and inorganic compounds in dentin tubules (Zappalà & Caprioglio, 1993).

Carbamide peroxide [CO ($NH_2$) $2H_2O_2$] is an organic white crystalline compound and is formed by urea and hydrogen peroxide and used in different concentrations. In a hydrophilic medium, it breaks down into approximately 3% hydrogen peroxide and 7% urea. Currently, it contains the most popular commercial bleaching preparations carbamide peroxide usually containing different concentrations of glycerin because it makes it more chemically stable than hydrogen peroxide. %10 carbamide peroxide which is bleaching agent, showed higher antibacterial effect than 0.2% chlorhexidine solution (Gurgan et al 1996).

Sodium perborate is an oxidizing agent available in powder form. It is stable when it dries; however, in the presence of acid, warm air or water, sodium metaborate is broken down to form hydrogen peroxide and newly formed oxygen. Sodium perborate is easier to control and safer than concentrated hydrogen peroxide solutions (Plotino et al 2008).

**Intracoronal Bleaching Techniques in Endodontically Treated Teeth**

**Indications for Intracoronal Bleaching**

- Discoloration from the pulp chamber,
- Dentin discoloration
- Discolorized teeth with root canal treatment
- In devital teeth covering one or more teeth for reasons such as trauma
- The basic principle of intracoronal bleaching is to start from simple and conservative practice. When there is no result, bleaching agent should be switched to which is a more effective agent (Hargreaves & Berman, 2015; Ingle, Bakland, & Baumgartner, 2008).

**Intracoronal Bleaching Contraindications**

- Superficial enamel discolorations
- Defective enemal formation
- Presence of caries

- Discolored composites
- When there are large defects in the form of fracture or cracked and require restored, severe dentin loss
- If there are pathological changes in the tissues around the root and servical
- Periodontal problems (Hargreaves & Berman, 2015; Ingle et al., 2008).

Endodontically treated teeth bleaching that comes out with chromatic changes is a more conservative approach than crown or veneer applications.

**Preliminary Treatment**

The success of intracoronal bleaching methods in devital teeth is mainly; depends on the reason for the coloring, the correct diagnosis of the problem and the correct selection of the bleaching technique. The cause of the patient's tooth discoloring should be determined. First, the tooth surface should be cleaned and determine the degree of color change of the tooth. Therefore, it is necessary to have a preliminary professional hygiene treatment (cleaning and polishing tooth surfaces) before starting bleaching. It is necessary to inform the patient about the causes of coloration, treatment method, prognosis, possibility of recoloring(Attin, Paqué, Ajam, & Lennon, 2003; Baratieri, Ritter, Monteiro, Caldeira de Andrada, & Cardoso Vieira, 1995).

Clinical photos should be taken at the beginning of the treatment and while the treatment process is ongoing. These will be a reference for future color comparison after bleaching (Plotino, Buono, Grande, Pameijer, & Somma, 2008). Clinical and radiographic examination should be done to determine the condition of the periapical tissues and the quality of the root canal filling. Retreatment should be done in unsuccessful or suspicious, insufficient root canal treatments. Bleaching should be done at least 7 days after root canal treatment (Attin et al., 2003; Baratieri et al., 1995). The color and quality of the existing restorations should be evaluated, missing restorations should be completed with temporary restorations, caries should be removed if any, after the bleaching process, permanent restoration should be performed according to the color of the tooth (Plotino et al., 2008).

## Devital Bleaching Techniques

### 1- Walking Bleaching Technique

Shaping the access cavity and removing old canal filling materials and sealer in the pulp chamber is one of the most important steps in the bleaching process. The pulp horn and other areas that could potentially contain pulp tissue should be completely cleaned. Labial perforation should be avoided. It is important to use Rubber-Dam to prevent the bleaching agents from leaking into the gum (Ahmad, 2009; Plotino et al., 2008). Floss, light-curing blockouts, wedges can be used for better isolation (Hargreaves & Berman, 2015; Plotino et al., 2008). A small cotton pellet impregnated with a suitable solvent (orange solvent, chloroform or xylol) can be used to dissolve sealer residue (Attin et al., 2003). For disinfection, it is recommended to irrigate the cavity with sodium hypochlorite (NaOCl). White cement barrier, such as polycarboxylate cement, zinc phosphate cement, glass ionomer, intermediate restorative material (IRM) (Dentsply/ Caulk, York, PA, U.S.A.), white colored MTA (Dentsply/Tulsa Dental, Tulsa, OK, U.S.A.), or Cavit (3M ESPE, St. Paul, MN, U.S.A.) (Hargreaves & Berman, 2015; Steiner & West, 1994) should be placed on the root canal filling as a protective barrier of sufficient thickness (at least 2mm) (Hansen-Bayless & Davis, 1992). Thus, the formation of cervical resorptions and damage of the periodontal ligament is prevented (Steiner & West, 1994).

This technique was first introduced by Salvas (Salvas, 1938). Sodium perborate and sterile water 2: 1 (g / mL) are mixed with an inert one such as saline or anesthetic solution to obtain a mixture of wet sand consistency. It can be obtained by mixing sodium perborate with hydrogen peroxide in varying concentrations (3% -30%) instead of water. Thus, with more oxidant, the bleaching effect and speed of the paste increases, while the risk of cervical resorption may increase (E. Nutting, 1963; E. B. Nutting & Poe, 1967). It has been reported in long-term studies that there is no significant difference between sodium perborate and sterile water mixture between sodium perborate and hydrogen peroxide mixture (Holmstrup, Palm, & Lambjerg-Hansen, 1988; Rotstein, Mor, & Friedman, 1993; Rotstein, Zyskind, Lewinstein, & Bamberger, 1992). The mixture is applied to the cavity. A paste is placed using an amalgam carrier. Then it is compressed with a plastic hand tool. The excess is removed by pressing the liquid cotton pellet. A small cotton pellet is placed on the paste and a 3mm thick filler is put on it (Hargreaves & Berman, 2015). After bleaching, the access cavity should be restored to prevent bacterial recontamination and leakage of stain-removing agents. A hermetic restoration plays an important role in bleaching treatments (Abou-Rass, 1998; Baratieri et al., 1995). An appointment should be made for the next session by informing the patient. Color change in the tooth should be

checked between 3-10 days. If color change is not observed in the case after 3 or 4 applications, diagnosis and treatment planning for different etiological reasons have to be re-evaluated. Hydrogen peroxide can affect the binding of composite resins to dental hard tissues. For this reason, it is recommended to completely remove the residual hydrogen peroxide before performing the composite restoration. Radiography should be taken after treatment and the bleaching agents should be neutralized by washing the access cavity with sodium hypochlorite (catalase or sodium ascorbate) (Rotstein et al., 1993) and put calcium hydroxide (CaOH2) in the pulp chamber and leave for at least 7 days (Demarco, Freitas, Silva, & Justino, 2001). Permanent restoration should be done within 1 to 3 weeks. The patient's tooth color should be followed annually by performing periapical radiographs. ("Consensus report of the European Society of Endodontology on quality guidelines for endodontic treatment," 1994)( Fig 1). It has been reported in studies that the treatment of patients with serious discolorings due to tetracycline coloration has been successfully performed with this technique (Anitua, Zabalegui, Gil, & Gascon, 1990; Fields, 1982; Lake, O'Dell, & Walton, 1985).

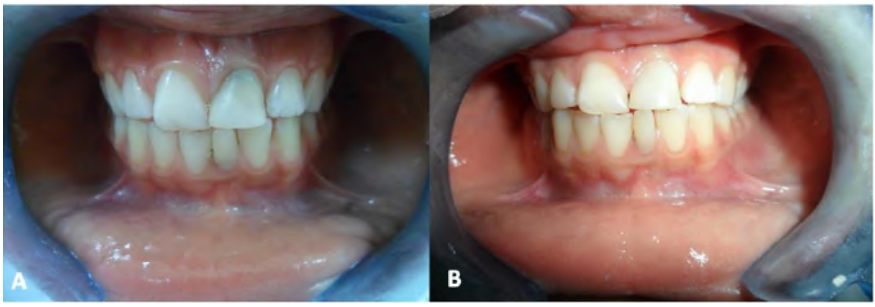

Figure 1: Walking Bleaching Technique A: Before B: After

**2- Thermocatalytic Bleaching**

Due to the strong interaction between hydrogen peroxide and heat, it has been proposed as the best technique for bleaching devital teeth (Kopp, 1973; Tewari & Chawla, 1972). However, due to the increased risk of cervical root resorption when using this technique, the walking bleaching technique seems to be more appropriate today. The preparation phase is the same as walking bleaching technique. Putting the oxidizing agent in the pulp chamber (usually 30-35% Hydrogen Peroxide) can be heated by electric heating devices (eg, Touch'n Heat, System B; SybronEndo, Orange, CA; SuperEndo Alpha, B&L Biotech, Fairfax, VA) or specially designed lamps (Hargreaves & Berman, 2015). Heat application will cause the hydrogen peroxide to foam, and then free radical oxygen to be released. It has been observed that the application of heat causes a reaction that increases the bleaching properties of hydrogen peroxide. This application

should be repeated 3 or 4 times in the office environment. Bleaching agent should be renewed in each application. Great care must be taken to prevent overheating of the teeth, periodontal ligament and gum tissues. Regular cooling breaks are recommended. As with walking bleaching technique, the procedure for applying temporary filling material between sessions should be carried out (Hargreaves & Berman, 2015; Plotino et al., 2008).

### 3- Ultraviolet Photooxidation

In this technique; Bleaching is performed by applying ultraviolet light instead of bleaching lamp to the labial surface of the tooth. 30-35% hydrogen peroxide is placed in the pulp chamber and then U.V light is applied from the labial surface of the tooth 2 minutes. The oxidation formation is occured, just as in the thermocolytic method (Lin, Pitts, & Burgess, 1988).

### 4- IN-Office Technique

Some authors have reported that external bleaching application with high concentrations (15-35%) carbamide peroxide gels or hydrogen peroxide (between 25% and 38%) yielded a successful clinical results (Frazier, 1998; Swift, 1992). High concentrations of hydrogen peroxide solutions are thermodynamically unstable and may explode if not stored in dark bottles in the refrigerator (Hargreaves & Berman, 2015). The tooth is isolated with a rubber dam. Damage to soft tissues should be avoided. The whitening gel is applied on the tooth without opening the access cavity (Carrillo, Arredondo Trevino, & Haywood, 1998; Liebenberg, 1997). They can be activated with light activation by special lamps. Some authors, on the other hand, recommend reaching the access cavity in terms of the deep penetration of the bleach gel during bleaching. Since the access cavity is not covered in this technique, there is a risk that bacteria will penetrate the dentin tubules and form stains. This risk can be seen even in good-filled root canal filling. Therefore, a restorative material such as glass-ionomer or resin composite should be used to seal the root canal hole.

## OUTCOMES

There are various alternatives in treating discoloured teeth. Considering right indication, to improve the estethic aspect of the treatred teeth, bleaching of the devital teeth endodontically comparatively is a low risked operation. Depending on the case, Walking bleaching technique could be none complex, the most appopriate method for both patients and the doctors. In Office bleaching technique generrally, to degree depending on the dehydration of the tooth, can only be temporarily successful.Taking in account, Existing data risk of the root resorption cannot be determined completely. It is known that bleaching in traumatized tooth trigger cervical resorption. Prevention of sufficient cervical leak tightness and

thermocatalytic method can minimize the risk of the resorption. By adding, radical cleaners like tiyocarbamid or using sodium percabonate traditional bleaching materials be in develop more its seems to be encouring in terms of minizing the effect of hydrojen to periodontal cavity. After bleaching, when colour changes come back, restorative treatment and prosthetic treatment can be considered.

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# CHAPTER VIII

# OCCLUSION AND DIGITAL AGE: TRADITION IS AGAINST INNOVATION

Assist Prof. Dr. Niler ÖZDEMİR AKKUŞ*& Dr. Makbule Heval ŞAHAN**& Prof. Dr. Övül KÜMBÜLOĞLU***

*Okan University, nilerozdemir@gmail.com, Orcıd ID: 0000-0001-7517-7562

**Ege University, hevalsahan@gmail.com, Orcıd ID: 0000-0003-0825-8914

***Ege University, t_ovul@yahoo.com, Orcıd ID: 0000-0002-4041-7308

Ideal occlusion can be defined as the occlusion, which is in harmony with the components of stomatognathic system, provides effective chewing and a good aesthetic without disturbing physiological functions. Occlusion types can be classified as; canine-guided occlusion, bilateral balanced occlusion and group function occlusion. In the canine-guided occlusion, there is no contact between the posterior teeth when the incisors are sliding on a straight protrusive movement. Only canines are in contact at the working side during lateral movement on both sides (Hobo & Takayama, 1997). Bilateral balanced occlusion: During the straight protrusive movement, both posterior and anterior teeth are in contact. While canines contact at lateral movement, also posterior teeth contact on both sides. Group function occlusion: during the straight protrusive movement, the incisors are in end-to-end position, but there is no contact at the posterior teeth. Both the posterior teeth and the canines are in contact on the working side at the lateral movement. At the balance side, there is no contact between the posterior teeth. These occlusion types should be arranged in accordance with the type of the prosthesis. Regardless of the construction technique of the prosthesis either digital or conventional, the correct occlusion establishment and arrangement is of great importance for the long-term success of the prosthesis. Factors affecting occlusal stability should be determined and taken into account in the design phase of the prosthesis. It has been reported that ideal occlusion can be attained in the position of the condyles in the centric relationship at maximal intercuspal position for functional movements to be performed comfortably and for the muscles to work well (Posselt, 1973).

Occlusion is controlled and arranged in the centric relationship using materials such as articulating paper, occlusion waxes and silicone materials for conventional prosthesis. Articulators have been developed that can perform functional analysis of masticatory muscles with the need to diagnose possible occlusal pathologies. The articulator gives dentists the opportunity to study the location and number of teeth in contact with the various movements of the mandible, as well as analyze the patient's

occlusal model. The reason why this method is not widely used is the difficulty in performing occlusal paterns during application (Dawson, 1989). With the development of photo-occlusion over time, it has been possible to determine the relative strength between tooth contacts. (Cartagena, Sequeros & Garcia, 1997).

Various occlusal analysis methods are used in order to arrange the occlusion nowadays. Occlusal indicators are used to identify occlusal contacts. The clarity of these indicators is essential for occlusal compliance and occlusal management. Although occlusal analysis and arrangements depend on precise records, it has been reported that only a tiny part of it depends on the clarity of the recording materials (Millstein, 1983; Schelb, Kaiser & Bruckl, 1985). The precision and reliability of the techniques used today for occlusal analysis depend on the thickness and resistance of the materials, the elasticity of the recording materials, the oral conditions, and the clinician's practice. (Dawson, 1989; Schelb, Kaiser & Bruckl, 1985). Various methods are currently used for occlusion analysis.

- Articulation papers
- Occlusion waxes
- Silicone materials
- Photo occlusion

Both qualitative and quantitative methods are used to evaluate occlusal relationships (Schelb, Kaiser & Bruckl, 1985; Sequeros, Garcia & Cartagena, 1997).

By the use of qualitative methods, only the localizations of the occlusal contact points can be determined, but the sequence and intensity of these contacts cannot be evaluated. The intensity of the contacts may be related to the darkness of the marks on the contact, but this is not an exact criterion for evaluation (Saracoğlu & Özpınar, 2002).

The most commonly used qualitative indicator for determining occlusal contacts in the mouth is articulation papers. They differ in width, thickness and being impregnated with various dyes. They simply consist of a color agent and a bonding agent between two film layers. While in occlusal contact, the colored agent is released from the film layer and the bonding agent allows this layer to adhere to the tooth surface. An area surrounded by dye is formed on the tooth surface, which is the area where the contact exists and is expressed as "target" or "iris". The density of these marks does not indicate that the occlusal load is excessive. Over loads cause the dye to be dispersed to the periphery of the contact point.

Extreme contacts also mean that it is necessary to make an arrangement only in the center of the marked area to avoid premature contacts

Although articulation papers are the most frequently used occlusal indicators among the clinicians, they have some limitations (Kürklü, Yanıkoğlu & Gözler, 2009).

- It marks a large number of pseudo contacts due to its inflexible structure.
- Their marking capacity is very low under low pressure especially on polished surfaces (such as porcelain).
- Since they are easily affected by saliva and deteriorate, they should only be used in dry areas.
- Their thickness (40μm) is considerably higher than the patients' perception level of thickness.

Some researchers have stated that silk bands are the best material for determining occlusal contacts (Schelb, Kaiser & Bruckl, 1985). Due to the nature of their texture, soft indicators create false contacts. However, the drying of some substances included in their structure causes the loss of their marking properties, and these substances are also affected by saliva. Therefore, these materials should be kept in a cool and closed place (Reiber, Fuhr, Hartmann & Leicher D, 1989).

Among the quantitative methods used in the evaluation of occlusal relationships; T-Scan and photo-occlusion systems are distinctive in determining the sequence of contacts and their density (Bottger & Borgstedt, 1989; Maness et al., 1987).

Photo-occlusion system: In this system, a thin photo-plastic film is placed on the occlusal surface of the teeth and the patient is asked to close the teeth for 10 to 20 seconds. This film layer is removed from the mouth and examined under polariscope light. This technique has been described as difficult to implement (Millstein, 1983). Occlusal contact points can also be determined by measuring the sensitivity with electro-optic, piezo-electric and resistance systems.

A new computerized occlusal analysis system was reported by Maness et al. in 1987. This system, named T-Scan, images and analyzes occlusal contact information with a pressure sensitive sensor. T-Scan, Occlusal Analysis System, is a system that allows the measurement of occlusal contact data. This system consists of a sensor, handle, processing unit, operating system and an installed printer. In T-Scan system, the main device is the sensor. Since it is an inexpensive material, it is used at periodic visits of patients and then discarded. It is 60 mm thick and

consists of a polyester film layer. Its characterized properties such as elastic deformation capacity and perforation resistance allows the material to measure the pressure. When the patient bites the sensor correctly, it makes the bite force turn into data on the screen. In this system, parameters such as biting time, exact occluding duration of teeth and the occlusal strength are determined. It has been reported that this system has great potential as a clinical tool in the diagnosis and treatment of occlusal disorders, due to its accuracy in determining occlusal contacts. All we need is that the patient to bite the sensor strongly (Cartagena, Sequeros & Garcia, 1997).

T-Scan system can be used where full arch occlusal contact is required;

- Complete dentures
- Fixed and removable partial dentures
- Full mouth restorations
- Implant supported restorations
- Occlusal adjustment in natural teeth
- Occlusal splints.

T-Scan occlusal analysis system works;

The first step in the T-Scan system is to prepare a working model from the patient. For this reason, the sensor is placed in the patient's mouth by controlling the midline that the marked part is in the middle of the upper central incisors. Then the patient is asked to bite so that the teeth are in full contact. In this study, the dental arch should be divided into four regions to minimize errors. Right posterior, right anterior, left posterior and left anterior region. The intensity of occlusal contacts is expressed in colors on the computer screen. Starting from blue extends to orange and red, red denoting the greatest strength.

Reza, Moini and Neff (1991) used silk articulation papers against the T-scan system in their study comparing repeatability in determining occlusal contacts and reported that pressure sensitive sensors do not give as accurate results as silk paper. However, many errors were found in this study. In the studies, it was stated that the ability to discriminate was limited due to the limited flexibility and high thickness that cause the mandible to move slowly and the sensor found highly variable results, the reliability of the sensor was questioned due to its low sensitivity (Patyk, Lotzmann, Scherer & Kobes,1989; Yamamura et. al, 1990) Some researchers have supported the use of T-scan as an occlusal diagnosis method, reporting it as an effective tool in occlusal therapy and patient

follow-up ( Bottger & Borgstedt, 1989; Combadazou, Combelles & Cadenat, 1990).

All these applications having advantages and disadvantages in different aspects are the techniques that are required for the mounting of prosthesis prepared with conventional methods and have been used for many years. Today, digital workflows have replaced clinical and laboratory processes with the advances in digital dentistry. The fabrication process of a prosthesis prepared with conventional methods consists of impression taking, wax modeling, investing, casting and polishing. These processes require considerable effort from both the clinician and the technician, and bring risks and difficulties such as high costs, long production times, damage to the impression or cast. Since its introduction in the late 1980s, Computer-Aided Design and Computer-Aided Manufacturing (CAD-CAM) technology has allowed clinicians to perform cleaner workflows, while technicians can prepare higher-quality work at lower cost and shorter production times. (Duret, Blouin & Duret, B, 1988; Davidowitz & Kotick, 2011).

A typical CAD-CAM workflow consists of 3 steps:

1. Converting geometry into digital data using an intraoral scanner or a lab scanner
2. Data processing using CAD software
3. Manufacturing using a milling machine or 3D printing technology.

The use of CAD-CAM system for prosthesis fabrication provides many convenience and has a wide range of usage for prosthetic procedures (Davidowitz & Kotick, 2011). CAD-CAM prosthesis have similar properties comparing conventional prosthesis in terms of marginal fit, aesthetic and mechanical properties (Johnson et.al. 2017; Nakamura, Dei, Kojima & Wakabayashi, 2003). However, almost all prosthesis produced by CAD-CAM technique are produced in maximum intercuspal position by ignoring the patient's eccentric movements and dynamic occlusion. This deficiency in the system requires occlusal arrangements to be made in the mouth and causes prolongation of appointment periods. These chair-side arrangements may cause both the deterioration of the occlusal shape formed with CAD software and the weakening of the mechanical properties of the material by causing a transition from the tetragonal phase to the monoclinic phase in a material such as zirconia (Karakoca & Yilmaz, 2009).

CAD designs therefore focus on the idea of transferring dynamic occlusion to virtual articulators. However, this process is thought to be long lasting. Although some studies have been done to simplify the

transfer of gypsum models from the mechanical articulator to the virtual articulator, this process still requires expensive and very large volume devices (Stavness, Hannam, Tobias & Zhang X, 2016; Solaberrieta, Minguez, Barrenetxea, Otegi & Szentpetery, 2015). Recently, different attempts have been made to enable the transfer of lateral movements to the virtual articulator. Park, Kim & Shim (2017) aimed to transfer the dynamic occlusion to the virtual articulator using CAD software by making lateral movements to the scanned models and recording the positions of the models lateral excursion. By means of this new digital workflow, the abrasions that need to be done on the occlusal surface could be seen in a virtual environment and the prosthesis was fabricated without disturbing the existing guidance. The definitive prosthesis design shows a reduced cuspal height and cuspal inclination compared with the prosthesis designed by the general workflow. In addition, adding some volume to the surface of the newly fabricated restoration can help to reconstruct group function or canine-protected articulation which is harmonized with the patient's existing occlusion (Park, Kim & Shim, 2017). However, the digital workflow still has some limitations. First of all, the excursion path is thought to be linear. The maximum intercuspal position's interocclusal record and the lateral interocclusal record only provide information about the starting point and the end point of the excursion on the working side. For the correct transfer of occlusal replication, other eccentric movements need to be considered, including protrusive and non-working side lateral movement and records must be taken for the moments between these two extremes.

Moreover, the movements of the protrusive and non-working sides should be taken into account in order to transfer the occlusion completely. With such additions that can be achieved in digital workflows, the chair time required for occlusal adaptation will be reduced and the occlusal anatomical shape prepared by the software will also be preserved.

Recent developments have increased the control and accuracy of both the process and the design of the definitive product. The design process for dental restorations can be more closely monitored and tailored to the patient's requirements. Despite the increased accuracy and time-saving potential of digital impression, cast fabrication, and mounting techniques, many dental laboratories still work with mechanical devices such as conventional casts, occlusal records, and mechanical articulators (Ghazal & Kern, 2010; Toledo, 1998). In addition, some companies have customized the virtual articulator for computer-aided design / computer-aided manufacturing (CAD/CAM) systems. However, it is still necessary to transfer the patient's models to a mechanical articulator first and then transfer the data obtained from the records to the virtual articulator

(Szentpétery, 1997; Gaertner & Kordass, 2003). It should be kept in mind that each additional step may decrease the restoration fit.

Every user considering digital technologies should consider initial cost and manageability as well as other aspects such as accuracy and time consumption. Each new technology has to be compared with the traditional one in order to evaluate its use.

In the fabrication of prosthesis using digital technology, occlusion is the most compelling component regarding the transfer to virtual environment. Various attempts have been made in the studies to test the compatibility and consistency of occlusion with the conventional method, which is tried to be transferred by digital workflow. Solaberrieta, Otegi, Goicoechea, Brizuela, Pradies (2015) tested the virtual occlusal contacts with the physical contacts obtained by using a conventional interocclusal record in vitro. They evaluated the digital procedure to locate the relative position of the digital casts with a virtual occlusion.

If the stages of this technique are summarized;

- Conventional impressions were obtained from the patient.
- Gypsium mounted casts were transfered to a semi-adjustable articulator with no recording material in between at maximum intercuspal position using a face bow.
- Occlusal contacts registered by 8-mm articulating film on the casts and were assumed to represent actual clinical contacts.
- 3-dimensional (3D) scanner was used to digitize the casts and to obtain their virtual occlusal records.
- The occlusal contacts determined physically on the stone casts were then contrasted with the virtual contacts obtained by digitizing and using reverse engineering software.
- Casts were scanned with 8 to 10 image captures, digitizing the entire occlusal surface.
- Casts were mounted on the mechanical articulator, and 3 to 4 image captures were made from the buccal side.
- Each articulator was locked to eliminate lateral and protrusive excursions, ensuring that the same occlusal contacts for the opening/closing movement.
- The mandibular casts were hand-articulated and mounted in MIP without an occlusal record. Then, the occlusal contacts were determined in MIP with the articulating paper

- The occlusal relationship in MIP was digitized with the 3D scanner.

- A comparison of the occlusal contacts was carried out with photographs and by superimposing them on screenshots of the software, taking as a reference the areas of the casts.

- All the points of the occlusal surface were compared (point by point) to obtain an overall deviation and a colored deviation map.

- Different reverse engineering software programs were used to align the images and calculate deviations.

- In this manner, virtual contacts on the digital casts were compared with the contacts obtained with the physical articulating paper. The location of the contact was based on anatomic regions as described and used by DeLong et al. (2002).

Many dental CAD / CAM systems use virtual occlusion to position the lower jaw model in the virtual articulator, but the procedure lacks validation as it is studied only a few times. Since 2002, cast models have been used in most of the virtual occlusion studies (DeLong et al., 2002; DeLong et.al., 2007). Recently, lower standard deviation values have been achieved in the transfer of virtual occlusion with 3D scanners, that features have been improved. Straga (2009) concluded that the stereolithography (stl) file quality is important because it measures the accuracy of the stone cast. In order to carry out the alignment, some of the operations are manual and other operations are automatic. To ensure the reproducibility of the process, only the automatic operations were carried out to get more objective and consistent results. In addition, the casts were mounted without any interocclusal record because many authors have stated that the use of the occlusal records changes the relative position of the maxillary and mandibular casts, it was recommended to transfer the models to the articulator without any interocclusal recording material in between (Tejo et.al, 2012; Ghazal&Kern,2010). Virtual contact is expressed as surface area, while physical contact is marked with articulating paper. Different surface areas can be determined depending on the movement of the antagonist tooth having the same marked area.

The contacts observed in the virtual environment were significantly more accurate than those of the physical ones and provided more objective and meaningful data. However, in order to ensure the reliability of the data provided us by digital technologies, the consistency of data transfer from the clinic or the laboratory and the standard deviation values should also be reduced to lower levels.

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# CHAPTER IX

# IMPRESSION MATERIALS IN ALL ASPECTS

Prof. Dr. Övül KÜMBÜLOĞLU* & Ar. Gör. Dt. Beril KOYUNCU**

*Ege University Faculty of Dentistry, Department of Prosthodontics, Izmir, Turkey e-mail: t_ovul@yahoo.com, Orcid ID: 0000-0002-4041-7308

**Ege University Faculty of Dentistry, Department of Prosthodontics, Izmir, Turkey e-mail: berilkoyuncu35@gmail.com, Orcid ID: 0000-0002-1744-5351

## Historical Perspective of Impression Making and Materials

A dental impression is defined as "a negative imprint or a positive digital image display of intraoral anatomy used to cast or print a 3D replica of the anatomic structure that is to be used as a permanent record or in the production of a dental restoration or prosthesis" in the Glossary of Prosthodontic Terms (Ferro et al., 2017).

The impression-making for a prosthesis dates back to old times. A German military surgeon, Gottfried Purman, recorded the use of wax in order to make impressions of jaws and teeth for the first time in the mid-seventeenth century. In 1756, Philip Pfaff used 2 pieces of wax to obtain the impressions for edentulous jaws and made a cast using Plaster of Paris (Ward, 1961). In 1844, three dentists named Dunning, Dwinelle and Westcott recorded the first use of Plaster of Paris as an impression material (Harris, 1845). Between 1845 and 1900, some basic principles of impression-making for fabricating a complete denture were introduced: Atmospheric pressure concept, maximum extension of denture bearing area, equally dissipated pressure and perfect adaptation to the denture supporting tissues (Essig, 1896; Harris, 1845; White, 1895). Prior to this era, it was thought that a single impression was enough but in these years, a secondary impression was started to be made of the preliminary plaster models (Essig, 1896; White, 1895). In the years between 1900 and 1929, closed mouth impression technique was first applied and different ways of border moulding were described such as sucking and swallowing movements, moving of the peripheral muscles in the direction of the attachments and in the opposite direction. Reversible hydrocolloids were first introduced in 1925 (Schulein, 2005). 1930-1950 were the years when muscle physiology was given significance and zinc-oxide eugenol materials were firstly introduced (Doxtater, 1936). Later, irreversible hydrocolloids were begun to be used in 1947 (Hansson & Eklund, 1984; Starcke, 1975). In 1952, non-pressure alginate impression technique was described for the first time after observing inflamed and sore areas following the fabrication of the dentures made by pressure impression technique (Denen, 1952). In the 1950's, the condensation silicones and polysulfides were started to be used often. Nevertheless, all these materials

had a great disadvantage: the polymerization shrinkage. This was related to the loss of water in hydrocolloids and the evaporation of low-side molecular products in elastomers (Clancy, Scandrett, & Ettinger, 1983; Lin, Ziebert, Donegan, & Dhuru, 1988). The polyether was first introduced in the late 1960's which was more hydrophilic than all of the known elastomers. It had a good flexibility, small amount of polymerization shrinkage and well mechanical properties. Approximately 10 years later, polyvinyl siloxane (PVS) was introduced to the market which was a hydrophobic impression material having an addition-based polymerization reaction. The elastic recovery of the material made it superior to the other elastomers and hydrocolloids. The surfactants were added to the composition of the material in order to decrease the hydrophobicity in the last era. It is famous with its good dimensional stability even in a moist environment (Christensen, 1997).

**The Evaluation of the Impression Materials**

In order to fabricate successful fixed or removable restorations, a qualified impression is a need (Naumovski & Kapushevska, 2017). Since fabricating a fixed or removable denture directly in the mouth is not possible due to high temperatures and dangerous chemicals, an indirect model of the case and capturing the exact condition of the teeth and the tissues are required. The most prevalent denture-related problems are inadequate retention and inappropriate jaw relations. Both problems are directly and indirectly related to the final-impression technique and the material which are used to fabricate the dentures (Kotkin, 1985).

Exhibiting some desirable characteristics is very important for the impression materials not only in the clinical practice but also in the laboratory stages. The yield strength, Young Modulus and the thermal expansion coefficient have to be optimal for better tearing resistance and elastic recovery. The materials have to be hypoallergenic as well since they are in contact with oral cavity. The pouring of the casts must be irreproachable and the prices should be low. Of course, having all these features for an impression material at the same time is a utopia (Anusavice, Rawis, & Kenneth, 2013; Craig, 2001; Mandikos, 1998; Panichuttra, Marietones, Goodacre, Munoz, & Keith Moore, 1991).

There are other different main valuation criteria which determine the technical quality of the impression materials and the preferability: accuracy, dimensional stability, flexibility and elastic recovery.

It is stated that an ideal impression material has to reproduce details in the area of 20 to 70 μm in the case of fixed partial denture restorations. The value alters to 100-150 μm when it comes to removable prosthesis (Rubel, 2007).

The accuracy of the impression material influences the precision of the prosthodontic restoration. According to ADA Specification #19, an ideal impression material has to exhibit a fine detail of 25 μm or less (Tjan, Li, Irving Logan, & Baum, 1991). The material should record all of the details and this is directly connected with the rheological factor and the viscosity of the impression material. Low viscosity prepares a better creepage in the oral cavity and the processing and setting time should be convenient as well in the meantime (Jerolimov, 2005).

The elastomeric impression materials are characterized in ISO Standards according to their consistency: Type 0 (putty) and type 1 (heavy-body) have consistencies lower of 35 mm. This means that the impressions with these materials should be prepared in one or two steps. Type 2 (medium-body) has a consistency between 31 to 41 mm and impressions can be made in single step. Type 3 (light-body) has a consistency of greater than 36 mm. A syringe can be used for making the impression (International Organization for Standardization, 2000).

There might be dimensional changes in the impression while the material is getting set or hardened and casting model process. These changes must be insignificant in order to obtain the best impression. The temperature of the oral cavity is approximately 37°C and for the pouring stone, the room temperature is nearly 23°C. This means that there is a 14°C of thermal difference affecting the contraction of the impression materials (Kambhampati, Subhash, Vijay, & Das, 2014).

The material should have an appropriate elasticity as well since there has to be no distortion while the undermined places are passed during the extraction of the impression tray (Jerolimov, 2005). It has to have the ability to return to its original dimensions after passing the undercuts and removal of the impression without any significant amount of distortion (Craig, 2001). Polyvinyl siloxanes are considered to have the highest elastic recovery followed by polyethers and polysulfides (Craig, 2001; Donovan & Chee, 2004). On the other hand, alginate is known as to be the most flexible impression material whereas the polyether is considered to be the most rigid amongst all (Rubel, 2007).

There are various well-known informative classifications of the impression materials in the literature regarding the composition, setting properties and setting reactions but the most commonly-used classification is related to the properties after the setting of the material. Impression materials can be classified as follows (Punj, Bompolaki, & Garaicoa, 2017):

- ✓ Conventional Impression
  - Elastic Materials

- Reversible Hydrocolloid
- Irreversible Hydrocolloid
- Polyether
- Polysulfide
- Addition Silicone (PVS)
- Condensation Silicone
- Vinyl Polyether Siloxane

- Inelastic Materials
  - Impression Wax
  - Impression Compound
  - Impression Plaster
  - Metallic Oxide Pastes

✓ Digital Impression
- Intra-oral Impression
- Extra-oral Impression

In this review, an indication-based classification is given preference.

**Impression Materials Used for Fixed Restorations**

In clinical dental practice, elastomers are commonly used in case of fixed prosthesis fabrication. Polysulfides, silicones and polyethers are the three main elastomers that are used especially for the impression of fixed prosthetic restorations. There are two types of silicones according to their polymerization reaction difference: Additional silicones and condensation silicones. Polyethers are known as the best detail recording impression material having an acceptable tearing resistance. On the contrary, polysulfides have better tearing resistance but are not as good as polyethers in terms of detail reproduction (Donovan & Chee, 2004).

The polymerization reaction of the condensation silicone is observed when dibutyl-tin dilaurate (DBTD) catalyzes a cross-linked polycondensation reaction of hydroxyl terminated polysiloxane pre-polymers with tetra alkoxy silanes. Then, alcohol is released following the polycondensation process that participates in the contraction of the impression. During the addition silicone (vinyl polysiloxane) polimerization, platinum plays a catalyst role and cross-linked polyaddition reaction of vinyl terminal polysiloxane polymers with mediation of methylhydrogen silicone takes place. Existence of platinum

in the reaction may release hydrogen from water or hydroxyl groups, This release of the hydrogen is accepted as the reason for the bubbles on the plaster model (Islamova et al., 2016).

The literature states that the linear contraction of the condensation silicones and addition silicones are 0.7 % and 0.22 % respectively at 24 hours (Anusavice et al., 2013). Panichuttra et al reported that the storage of the elastomeric materials influence the dimensional stability and found out that all polyvinyl siloxane materials' dimensional stability continued to decrease in 1 hour, 1 day and 1 week (Panichuttra et al., 1991). According to studies, the highest dimensional shrinkage during setting is observed in polysulfides and condensation silicones which are approximately 0.4 % and 0.6 % respectively. The volatile byproducts are the reasons for the dimensional shrinkage; the bonds are reorganized after the evaporation of these products. The dimensional shrinkage ratio of additional silicones and polyethers are 0.15 % and 0.2 % which are smaller than the other elastomers (Anusavice et al., 2013; Craig, 2001). Since, most of the practitioners prefer to send their elastomer impressions to the laboratory for pouring, the dimensional accuracy is very significant.

The hydrophobicity of vinyl polysiloxane is related to the chemical structure of the material, which contains hydrophobic-aliphatic hydrocarbon groups around the siloxane bond (Shen, 2003)**.** Polyether and polysulfide are more hydrophilic than VPS because of their chemical structures containing available functional groups that can interact with water molecules through hydrogen bonding. VPS has a high contact angle that typically forms when the impressions are wetted with dental gypsum materials (Chong, Soh, Setchell, & Wickens, 1990; Derrien & Menn, 1995; Pratten & Craig, 1989). From another aspect, the disadvantage of the hydrophobicity can be seen in the mouth during impression making, because the material has the lack of ability to wet oral tissues due to its surface energy (Chee & Donovan, 1992; Mandikos, 1998). As mentioned before, the hydrophilicity of the polyvinyl siloxanes has been improved by adding non-ionic surfactants in the composition. Wettability of the material has become better but still there should be a critical control of the moisture during the impression-making (Craig, 2001).

Addition silicones (VPS) are stated as the gold standard for the fixed restoration impressions. There are no byproducts formed, yet, platinum inside the composition produces hydrogen which might affect the surface of the cast model. The viscosity of the material depends on the amount of silica filler. The amount of silica filler determines the impression material either to be a putty material or wash material. Latex gloves or rubberdam have a risk of affecting the polymerization of addition silicones, since they consist of sulfur or sulfur compounds that usually cause a distortion in the

impression (Anusavice et al., 2013; Craig, 2001; Donovan & Chee, 2004). Another critical point is that, after a polyether or polysulfide impression is taken, a chemical film layer is formed on the surface of the tissues in the mouth. This film layer prevents the polyvinyl siloxane polymerization, so it is advised not to take an impression immeadiately if these two materials are just used (Donovan & Chee, 2004; Mandikos, 1998). Newer polyvinyl siloxane materials are stated as having components which prevents forming of hydrogen-bubbles and it is recommended that the impression should not be poured immediately; a 30 minutes of time has to be passed since the polymerization still continues outside (Anusavice et al., 2013). According to some other studies, the appropriate time to wait before pouring is 60 minutes whereas some manufacturers believe that the impression can be poured immediately (Powers & Wataha, 2017; Sakaguchi & Powers, 2012).

Polyethers contain a base paste which consists of a long-chain polyether copolymer with alternating oxygen atoms, methylene groups and reactive terminal groups. The catalyst paste contains a cross-linking agent, fillers and plasticizers. This material is known as to capture details very well even in the presence of blood and saliva. It allows multiple pouring of casts from the impression in 1 or 2 weeks of time without any signs of tearing (Craig, 2001; Giordano, 2000). It is commonly used for border molding or obtaining detailed impressions. The rigidity of the material is improved by new "soft" polyether compositions. The "snap-set" feature of the material allows not to set before the end of the working time and all material sets at the same time and immediately (Klettke, Kuppermann, & Fuhrer, 2004; Phoenix & Rodney, 2002). Presence of latex gloves does not affect the setting reaction (Rubel, 2007). The material is available in 3 different viscosities (high-medium-low) and it is used as a mono-phase material or in syringe-tray technique. Motorized mixing unit is the most common way to dispense the material (Punj et al., 2017).

Polysulfides have a base paste consisting of polysulfide polymer (with –SH terminal groups), titanium dioxide, copper carbonate, zinc sulfate, silica and a catalyst paste. The amount of titanium dioxide in the base paste determines the viscosity of the material. The polymerization reaction occurs by the oxidation of the –SH groups (Craig, 2001; Giordano, 2000). Since it is not too rigid, the impression can be removed from the mouth easier than polyvinyl siloxanes or polyethers and superior to hydrocolloids and polyvinyl siloxanes, the subgingival margin details can be captured without any tearing (Adabo, Zanarotti, Fonseca, & Cruz, 1999; Craig, 2001). It is not preferable due to its bitter taste, unpleasant smell and mercaptan and plumbum content (Kümbüloğlu & Türk, 2018).

Vinyl polyether siloxane materials were first introduced in 2009 in Germany (Identum, Kettenbach Co, Eschenburg, Germany) and the best properties of polyether and vinyl polysiloxane are combined in this material. It is easy to remove and has a good wettability but still more researches have to be made about this material (Punj et al., 2017).

On the other hand, the use of alginate in the fabrication of fixed restorations is common especially for the provisional restorations and for obtaining a study model for diagnostic purpose. The advantages of the alginate can be listed as: good wettability, easy tolerability of the material, low cost and simple instrumentation and technique (Petropoulos & Rashedi, 2003; Rubel, 2007). Detailed information about the material will be given later.

**Impression Materials Used for Complete Dentures**

Total edentulous patients are usually preferred to be treated by implants recently. Nevertheless, not all of the edentulous patients are suitable for the implant treatment unfortunately. The high costs of the treatment, the anatomical limit factors (bone height, bone quality etc.), systemic diseases, the anxiety for the surgery are some obstacles of the implant treatment which direct the clinician and the patients towards the traditional total denture treatment.

In order to provide the adaptation of the denture bases to the denture bearing areas, a perfect impression must be obtained with a peripheral seal. Improving the retention and stability enables the function to be more effective (Carlsson, Örtorp, & Omar, 2013). There are two types of complete denture impression techniques: Open-mouth and closed-mouth. In the closed-mouth impression technique, an ordinary preliminary impression is first taken and then when it comes to the secondary impression, functional or neutral zone impression techniques shall be preferred. The open-mouth impression technique can be applied in two ways according to the number of steps: Single-step or Two-step impression technique. In the two-step technique, after a preliminary impression, border moulding is completed either by the operator or functionally. The final impression can be obtained by choosing either one of the techniques: mucocompressive impression technique, mucostatic impression technique, functional impression technique, selective-pressure impression technique and neutral zone impression technique (Al-Ahmar, Lynch, Locke, & Youngson, 2008; Drago, 2003; Freeman, 1969; Paulino, Alves, Gurgel, & Calderon, 2015; Petropoulos & Rashedi, 2003).

Dental practitioners are likely to simplify the impression steps eliminating the number of appointments. This concludes with the single-step impression procedure which the alginate is used as the definitive

impression material (Hyde & McCord, 1999). However, most of the literature states that the conventional two-step procedure provides better early-stabled new dentures with a larger contact surface and less need of post-insertion adjustments (Komagamine et al., 2019).

The two-step procedure which consists of a preliminary impression with a stock tray using irreversible hydrocolloid and a secondary impression with a custom acrylic resin tray using various impression materials is advised usually for fabricating the complete dentures (Petrie, Walker, & Williams, 2005). Gypsum, Zinc-oxide Eugenol, Polyvinyl Siloxane, Polyether, Polysulfide can be given as examples for the final impression materials (Rao, Chowdhary, & Mahoorkar, 2010).

Border moulding is sufficient when obtaining a secondary impression with a custom tray in order to determine the extension of the prosthesis. According to the Glossary of Prosthodontic Terms, it is defined as "the shaping of impression material along the border areas of an impression tray by functional or manual manipulation of the soft tissues adjacent to the borders to duplicate the contour and size of the vestibule" (Ferro et al., 2017). It can either be made sectionally or single-step and the movements can be directed by either the operator or functionally. The sectional technique consists of the low fusing impression compound as the border moulding material (Friedman, 1957). In the single-step technique, different viscosities of polyether and additional silicone are used in common (Chaffee, Cooper, & Felton, 1999; Smith, Toolson, Bolender, & Lord, 1979; E. G. Solomon, 1973; E. G. R. Solomon, 2011)

When alginate is preferred for the secondary impression, a green stick impression material (Kerr) should be used for the border moulding of the custom trays (Basker, 2002). Border moulding of the light-body silicone impressions is advised to be made with heavy-body (Extrude, Kerr) or regular-body silicones (Express, 3M ESPE) (Basker, 2002; Chaffee et al., 1999).

Alginate materials are the most common impression materials for the secondary impression of complete denture restorations. In fact, alginates are the salts of alginic acid. Alginic acid is a polysaccharide extracted from the cell walls of brown algae belonging to the Phaeophyceae family which is widespread especially in America. Even though, alginate is insoluble in water, the alkaline salts of it are soluble in water and that is the reason why sodium or potassium alginate can be used in dental field (Spoto, 2013). In order to make the impression more stable dimensionally, +4°C temperature and a humid environment is sufficient so that the pouring can be delayed (Farzin & Panahandeh, 2010). Due to imbibition and dessication of the material, the dimensional stability is poor. Alginates that have two different setting-time are available on the markets: fast-setting (1-2

minutes) & normal setting (2-5 minutes) (Spoto, 2013). It can easily be removed from the mouth, but the tear resistance is quite low unfortunately (Craig, 2001).

In their review article, Jayaraman et al reported that there was untrustworthy evidence which stated silicone was a better secondary impression material for oral health-related quality of life than alginate (Jayaraman et al., 2018).

In general, the impression materials used for both Removable Partial Dentures and Complete Dentures can be listed as (Freeman, 1969; Verrett, 2008):

- For the border moulding
  - ✓ Low fusing impression compound (green stick)
  - ✓ Elastomers
- For the final impression
  - ✓ Impression Plaster
  - ✓ Elastomers
  - ✓ Fluid Wax
  - ✓ Alginate
  - ✓ Zinc-oxide Eugenol Impression Paste

**Impression Materials Used for Removable Partial Dentures**

Partial edentulism is more widespread than complete edentulousness (Jeyapalan & Krishnan, 2015; Slade, Akinkugbe, & Sanders, 2014; Tanasic, Tihaček-Šojić, & Milic-Lemic, 2015). The way of distributing the occlusal forces may vary regarding the indication whether the prosthesis is tooth-supported or tissue & tooth supported. Moreover, the remaining teeth should be preserved as well. These are the reasons why different impression techniques are applied. The classification of the final impression techniques for removable partial denture is as follows (Verrett, 2008):

- Tooth Supported Dentures
  - ✓ Preliminary (Diagnostic) impression
  - ✓ Final impression
- Tissue-Tooth Supported Dentures
  - ✓ Selective Pressure Impression Technique

- ✓ Physiologic Impression Technique
  - ❖ McLeans-Hindels Technique
  - ❖ Functional Reline Method
  - ❖ Fluid Wax Impression Technique

Different dual final-impression techniques and semi-precision attachments can be used to make cast partial removable dentures in order to help decreasing the stress transfer to the abutment teeth during occlusal loading, preserving the health of the remaining oral tissues (Blatterfein, Klein, & Miglino, 1980; Leupold, 1966).

In their study, Jayaraman et al included randomized clinical trial and crossover trial researches considering different impression techniques and different final impression materials used for removable partial dentures and discussed the results in detail. They included studies which alginate, zinc-oxide eugenol, elastomers, green stick and fluid wax were used (Jayaraman et al., 2018). These materials are known as to be the preferred ones for the removable partial dentures.

Occlusal adjustment is a requirement before insertion of the prosthesis because the removal of the prosthesis from the master casts ends up with dimensional changes. Usually, the original casts get broken after the flasking stage. Remount casts must be prepared in order to remount the prosthesis. After the removable prosthesis is placed in the mouth, an alginate impression is obtained and the prosthesis must remain in the impression. If not, it can be inserted in the impression carefully and passively. When pouring the impression, the occlusal/incisal 1/3 of the abutment teeth can be filled with an autopolymerising resin using dowel pins and the rest of the teeth can be filled with polyvinyl siloxane material. If there are gaps or undercuts in the impression or intaglio surface of the prosthesis, again PVS can be used in order to fill the gaps or block the undercuts (Hsu & Farmer, 2005).

**Digital Impressions**

CAD/CAM technology and intra-oral/extra-oral scanners provide an easy way of obtaining impressions from the mouth eliminating the risk of impression and model distortions. CAD/CAM systems were started to be used in 1980's in dental field by clinicians and laboratory technicians for fabricating inlays, onlays, crowns, fixed restorations, implant restorations and laminate veneers (Ahlholm, Sipilä, Vallittu, Jakonen, & Kotiranta, 2016).

The advantages of digital impressions are:

- o No risk of gagging reflex

- No tearing or dislocation of the impression from the tray
- Time efficiancy
- No risk of impression or model distortion
- Storage of patient data (Alghazzawi, 2016)

However, there are some disadvantages as well. Optical scans may have problems when detecting subgingival margins and distal surfaces of prepared teeth in case of bleeding and saliva. Patients with restricted opening may have difficulties with intra-oral scans inside their mouth. Also, purchasing the system is too expensive. It is stated that, in case of full-mouth restorations, conventional impression techniques have the ability to capture the details better than the digital impression. These might be the drawbacks for the use of digital workflow (Kümbüloğlu & Türk, 2018).

**Conclusion**

Obviously, the selection of the impression material and the technique and the clinician's experience are the most significant points in fabricating prosthesis. Clinicians have to be aware of the material properties and pay attention to the manufacturer's instructions. In daily clinical practice, considering the case and the indication, the impression material should be chosen carefully according to the material properties for the best results in order to end up with irreproachable and excellent prosthesis.

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