Prosthetic Therapy of Sports Injuries of the Teeth - Case Report

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PROSTHETIC THERAPY OF SPORTS INJURIES OF THE TEETH – CASE REPORT

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To my mom, who is my hero.

PROSTHETIC THERAPY OF SPORTS INJURIES OF THE TEETH – CASE REPORT

Summary

Sports injuries are traumas that occur accidentally in various sports rather often. Because of its anatomical position and prominence, the face, as well as the oral cavity and associated teeth are at a very high risk to become involved. Sport-related injuries may lead to severe consequences that have a negative impact on the physical and mental well-being of the injured person, particularly in young people. Especially sports disciplines that encompass a ball or racket are noticed to be dangerous for the athlete.

In most of the cases, it happens that the frontal teeth are injured or fractured. It presents an enormous problem to the injured person, as it involves an aesthetically visible area. Furthermore, trauma to the frontal region presents a difficulty to the dentist, too. The dentist has to not only decide the right time for the treatment procedure but also the accurate therapy plan. The choice of the treatment option depends on the type of the trauma.

Prosthodontics is the key to solving the effects of traumatized and fractured teeth. Prosthetic treatment options include the production of removable and fixed dentures as well as crowns. When combining prosthodontics with implantology even the most severe consequences such as loss of teeth can be treated.

In this thesis, a case of a young male patient who was 20 years old at the time of the trauma is documented. As a result of a football-related injury, the boy’s left central incisor fractured horizontally in the mid-portion of the tooth and received prosthetic treatment. A dental implant and a crown were placed after the extraction of tooth 21. A crown was also placed on tooth 11, which had undergone endodontic treatment before the sports trauma. Additionally, tooth 22 received restorative treatment due to a minor incisal edge fracture.

Since a young frontally visible permanent tooth is involved, it is of utmost importance to preserve its position in terms of aesthetics, function, and phonetics in the oral cavity.

Keywords: sports, facial injuries, fracture, teeth, loss, therapy, prosthetic treatment, implantology

PROTETSKA TERAPIJA SPORTSKIH OZLJEDA ZUBA

Sažetak

Sportske ozljede su traume do kojih često dolazi slučajno u raznim sportovima. Zbog svog anatomskog položaja i istaknutosti, lice, kao i usna šupljina i zubi, pod vrlo visokim su rizikom da budu zahvaćeni. Ozljede povezane sa sportom mogu dovesti do teških posljedica koje negativno utječu na tjelesno i psihičko stanje ozlijeđene osobe, posebice kod mladih. Osobito se primjećuje da su sportske discipline koje uključuju lopticu ili reket opasne za sportaša.

U većini slučajeva događa se da su prednji zubi ozlijeđeni ili slomljeni. Ozlijeđenom predstavlja veliki problem jer zahvaća estetski vidljivo područje. Nadalje, trauma frontalne regije predstavlja poteškoću i stomatologu. Stomatolog mora odrediti pravo vrijeme za postupak liječenja, kao i točan plan terapije. Izbor mogućnosti liječenja ovisi o vrsti traume.

Protetika je ključ za rješavanje posljedica traumatiziranih i slomljenih zuba. Mogućnosti protetskog liječenja uključuju izradu mobilnih i fiksnih proteza te krunica. Kombinacijom protetike i implantologije mogu se liječiti i najteže posljedice poput gubitka zuba.

U ovom radu dokumentiran je slučaj mladog pacijenta kojem je u vrijeme traume bilo 20 godina. Kao posljedica ozljede povezane s nogometom, mladićev je lijevi središnji sjekutić puknuo vodoravno u središnjem dijelu zuba i protetski je zbrinut. Zubni implantat i krunica postavljeni su nakon vađenja zuba 21 te je izrađena krunica na endodonstki liječenom zubu 11. Osim toga, zub 22 podvrgnut je restorativnom tretmanu zbog manje frakture incizalnog ruba.

Budući da je riječ o mladom, frontalno vidljivom trajnom zubu, od iznimne je važnosti očuvati njegovu estetsku, funkcionalnu i fonetičku poziciju u usnoj šupljini.

Ključne riječi: sport, ozljede lica, prijelom, zubi, gubitak, terapija, protetska terapija, implantologija

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List of abbreviations

EVA - ethylene vinyl acetate

PTFE - polytetrafluoroethylene

PMMA - polymethylmethacrylate

CT - cone beam tomography

FPD - fixed partial denture

RPD - removable partial denture

CEJ - cementoenamel junction

CCM - colorimeter

SPM - spectrophotometer

LED - light-emitting diode

FBP - fixed bridge prosthesis

RBFDP - resin-bonded fixed dental prosthesis

1. INTRODUCTION

Facial injuries are prevalent across numerous sports disciplines and may result in catastrophic consequences for athletes (1). Traumatic injuries can lead to loss of anterior teeth which impacts the quality of life and has an influence on speech, mastication, aesthetics, self-esteem, and mental and social well-being. Regarding the treatment plan in these scenarios, various factors need to be considered. The number of lost teeth, the remaining teeth, the occlusion, the available space, facial morphology, age, growth pattern, as well as the morphology of teeth will determine the final therapy (2).

The purpose of this specific case report is to document and analyze a unique and interesting case about the prosthetic therapy of a young patient after sports trauma to the teeth. The aim of this thesis is to mention the specific injury to the teeth and to present the prosthetic therapy as a solution. Also, the challenges faced in the treatment of sports injuries and prevention options for such injuries in general will be discussed.

1.1. Epidemiology of facial injuries in sport

Based on hospital-derived data, the risk associated with sports-related injuries exhibits variation across countries, depending on the popularity of specific sports in that respective region. Sports-related facial injuries may constitute up to 41% of the injuries observed at emergency departments of clinics. The primary sports contributing to facial injuries differ from one country to another, encompassing baseball, basketball, floorball, soccer, ice hockey, tennis, rink bandy, and cycling. Sports-related activities contribute to an outstanding proportion of fractures in the face, ranging from 4% to 41%, eye injuries from 0.3% to 24%, and dental injuries from 0.8% to 26% across various emergency departments globally (1).

1.1.1. Maxillofacial trauma

Regarding studies of facial injuries in emergency departments in Italy, Chile, and Germany soccer has been well-known to have the highest frequency of sports-related facial fractures (41.6-59.2%).

Maxillofacial injuries often encompass the midface complex, comprising 67% of cases, with notable occurrences of orbital floor fractures of the zygomatic bone (47%) and nasal bone fractures (26%). Additionally, injuries to the mandibular region account for 29% of cases, with mandibular fractures predominantly observed at the condyle or immediately below it. One study revealed that 19 out of 42 treated sports-related mandibular fractures implicated the condylar or sub-condylar region.

It is proven that adolescents and young adults appear to be more vulnerable to facial fractures compared to younger children (1).

1.1.2. Ocular injuries

According to a study investigating injuries of the eye in the United Kingdom patients with sport-related eye injury most often present with traumatic uveitis, commotion retinae, traumatic hyphema, and corneal abrasion. In addition, contusions show to be the most common sort of injury according to a study from Finland (1).

1.1.3. Dental injuries

Sport-related injuries that may affect the dentition include lacerations, fractures, avulsions, subluxations, periodontal disease, abscess, and pulpitis. Having a short upper lip and an overjet greater than 3 to 4 mm are known risk factors for such kinds of injuries (1).

1.2. Prevention of sports-related facial injuries

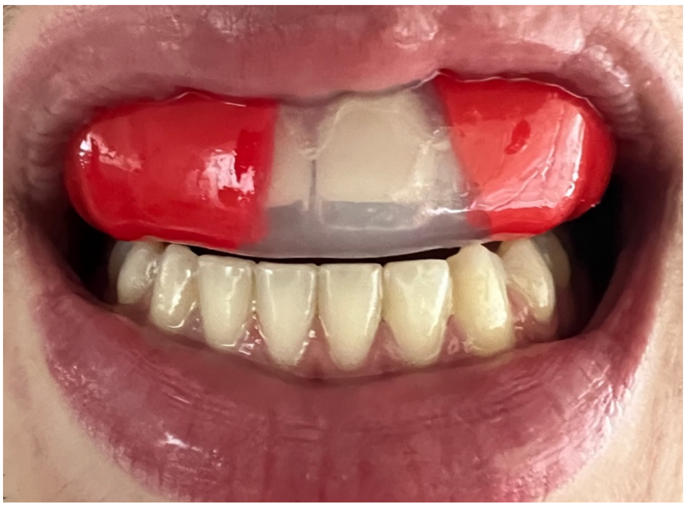
Primary preventive measures are crucial for the overall health of athletes as well as for continued participation in sports. There is some proof that face guards, mouthguards, eye protection, and helmets are effective in decreasing the risk of facial injury. However, these safety strategies are not universally adopted by all athletes who play high-risk sports. The reasons why someone may not accept this kind of measure lay in the beliefs about risk perception, lack of awareness or enforcement, comfort, utility, and ineffectiveness (3).

1.3. Mouthguards

The mouthguard, also known as a gumshield or mouth protector, serves as a resilient appliance placed inside the oral cavity for the reduction and prevention of injuries. This device primarily targets teeth and adjacent structures.

The purpose of the mouthguard is, therefore, the protection of the teeth, gingival tissue, lips, and jaws. Its efficacy lies in significantly diminishing the deflection of teeth under stress when compared to unprotected teeth.

An ideal mouthguard should exhibit qualities of protectiveness, comfort, durability, resistance to tears, freedom from odors and tastes, affordability, simplicity of manufacture, and minimal interference with speech (4).



Picture 1. Mouthguard inside the oral cavity of an ice hockey player

(Image used with permission from the author, prof. dr. sc. Sonja Kraljević Šimunković, dr. med. dent., Department of mobile prosthodontics.)

1.3.1. Materials and types

There are various materials used in the production of the mouthguard. Polyvinyl-acetate-polyethylene copolymer and polyvinyl chloride are most often considered. Less widely used materials are silicone rubber, natural rubber, soft acrylic resin, and polyurethane.

Regarding the most common types of mouthguards, there are three types to be specified. Type I or stock mouthguards are over-the-counter appliances with a design that is not modified further. Type II or mouth-formed boil-and-bite devices are designated as such due to commercial procurement. These mouthguards are composed of thermoplastic material which is subjected to immersion in hot water and subsequently formed within the mouth by the athlete utilizing the finger, tongue, and biting pressure. Type III mouthguard is a custom-made appliance characterized by the fabrication on a model of the patient's mouth (4).

1.3.2. Design and production

The design of the sports mouthguard should fit the most prominent arch exposed to injury. Mouthguards in the maxilla are the most used ones but those in the mandible are suggested for athletes with class III malocclusion.

Theoretically, the optimal ethylene vinyl acetate (EVA) thickness of the mouthguard should be approximately 4 mm for mechanical performance and shock absorption. Regarding general design recommendations, it is advised that the soft tissue coverage extends up to 2 mm from the vestibular reflection. Additionally, proper lip closure or the protective function of the cheeks and lips shouldn't be compromised. A palatal extension design of 6-10 mm is recommended. In the posterior area, the mouthguard should cover the most distal molars, with the occlusion adjusted to allow the jaw to maintain a physiologic position which aids in impact absorption. An accurate-fitting sports mouthguard is important for retention, as poor fit does not offer proper protection and may reduce compliance. Retention is strongly associated with the design and fit accuracy in the cervical undercut areas, and darker-colored mouthguards have been reported to enhance retention because of improved model adaptation, facilitated by greater heat absorption and better material flow.

The production methods of type III mouthguards involve pressure injection, vacuum thermoforming, and flasking techniques. Both pressure injection and vacuum thermoforming methods use a heating process in which the material is transformed to a moldable consistency.

Negative pressure is utilized in the vacuum method in order to pull the heated material onto the model. The working model height should be trimmed to 20 mm and 15 mm at the central incisor and first molar area. For sufficient mouthguard material thickness over the anterior teeth and sulcus, the ideal inclination of the model's anterior teeth is between 30 and 45 degrees. For molding EVA materials a temperature of 120 °C is applied, with approximately 15 mm of material sag during heating as an indicator of adequate forming temperature. The molding device vacuum should be initiated before placing the sagging material on the dental model. For optimal thickness, key considerations involve the model's position and angulation on the vacuum device platform, combined with laminated sheet manipulation. It is also suggested to center the model in the vacuum former, minimizing the distance between the model and the material frame, or to move the dental model forward by approximately 20 mm just before vacuum forming. Other recommendations involve the placement of a central groove in the laminated sheet, using two sheets of laminated material, sheet notching, and trying out different frame shapes to hold the laminated sheets.

In contrast, compressed air is used in the pressure injection technique to force the material onto the dental model.

When comparing these two techniques, the vacuum thermoforming method presents variable and reduced thicknesses, whereas there is even more thickness and better adaptation in the pressure injection technique. In addition, the vacuum-forming technique is faster and simpler, but more cost-effective.

The flasking technique describes a method that flasks and processes a mouthguard model in wax. A resilient resin is used for the processing step (5).

The fabrication of mouthguards for athletes undergoing orthodontic treatment is more challenging. These patients present with an increased risk of injury due to greater tooth mobility and the presence of orthodontic devices (4). For these patients customized protection with type III mouthguards is possible (5).

Digital fabrication of mouthguards is available but still under development. One important part of additive fabrication is the layer-by-layer technique of heated filaments placed from an extrusion head. This step is called the fused deposition modeling. Photopolymer jetting involves the use of a light-curable polymer, which is deposited on a building platform from an inkjet-type printing head and cured layer by layer (5).

2. IMPLANT PROSTHETICS

The introduction of dental implants for restoring missing teeth constituted a significant milestone in the field of dental rehabilitation.

The survival rate of implant prosthetic rehabilitations is notably high, approximately reaching 95% and remaining greater than 89% even after a period of 10 years.

Nowadays, digital implant procedures which include guided implant protocols have emerged as promising tools for simplifying conventional procedures for dental professionals (6).

An increasing demand and adoption of implant-based treatments in the future are influenced by multiple different factors. These include the aging population experiencing extended lifespans, tooth loss attributed to age, complications that arise from the failure of fixed prostheses, anatomical changes as a result of tooth loss, inadequate performance of removable dentures, consistently favorable long-term outcomes associated with implant-supported dentures, psychological implications of tooth loss and the evolving needs and desires of aging baby boomers, advantages of implant-supported restorations over traditional alternatives and increasing public awareness as well as acceptance of implant-based dental solutions (7).

2.1. Implant properties

The purpose of an osseointegrated dental implant is to address tooth loss in partial or complete edentulism. Also, implants can play an important role as a retaining element for removable prostheses. An implant mimics the function of the tooth's root and crown. The difference is that an implant lacks the susceptibility to decay and it does not contain a pulp or a periodontal membrane. In order to evaluate dental implants periodontal indices are taken into consideration. These indices encompass aspects such as longevity and mobility versus rigid fixation, percussion, bleeding index, probing depths, pain assessment, crestal bone loss, presence of keratinized tissue, radiographic evaluation, and peri-implant disease assessment (8).

2.1.1. Components, types, dimensions, and shapes

Root-form implants, categorized under endosteal implants, are manufactured to utilize a vertical column of bone analogous to the root of a natural tooth.

The most widespread design of the root form has an implant body separate from the implant abutment. Separation of these two elements permits only placing the body during bone healing. Attachment of the implant abutment is achieved in a second procedure. The abutment screw connects the body and the abutment of the implant. Furthermore, the implant body can be divided into a body, a crest module, and an apex.

The transfer of stress and strain to the bone during occlusal loads is accomplished by the implant body. In contrast, the crest module is designed to decrease the invasion of bacteria and retain the prosthetic element in a two-piece implant system. The abutment is seated on a platform located on the abutment connection area, providing physical resistance to axial occlusal loads. An anti-rotation feature, known as the external hex, is incorporated on the platform or may extend internally within the implant body, referred to as the internal hex. In addition, the crest module serves as a transition zone from the body to the transosteal region of the implant at the crest of the ridge.

The most prevalent and widely offered implant body design among manufacturers is the solid screw implant. In terms of diameters, the most usual outer thread diameter is 3.75 mm, with a thread depth of 0.38 mm and a thread pitch of 0.6 mm. The implant body lengths typically range from 7 to 16 mm, even though lengths from 5 to 56 mm exist.

Based on the design, three primary types of root-form body endosteal implants exist. They can present with a cylindrical design, a screw design, or a combination of the aforementioned. Comparable implant body designs are available in different diameters, such as narrow, standard, or wide, in order to address aesthetic, anatomical, and mechanical requirements in different areas of the oral cavity.

The surface of cylinder implants can be coated with a rough material or a macro retentive design aimed at providing microscopic retention to the bone. Rough materials such as hydroxyapatite or titanium plasma spray are used, whereas the macro retentive design employs sintered balls. Cylinder implants are placed into the prepared bone site by pushing or tapping. Two variations of the implant exist either as a parallel wall cylinder or a tapered design of the implant.

Screw root form designs are manufactured to be inserted into a slightly smaller prepared bone site. They are characterized by the macroscopic retentive elements of a thread for the initial fixation of the bone. Screw-design implants can be machined, textured, or coated. Screw-thread geometries come in three basic types: V-thread geometry, the buttress or reverse buttress thread, and the power or square thread design. Threaded implants can have micro or macro thread features, self-tapping features, and variations in thread pitch, depth, and angle and are available in either a tapered or parallel cylinder configuration. Because of its surface condition, the threaded implant can have a microscopic connection to the bone.

Combination implant designs combine macroscopic features from cylinder and screw root form implants. Various surface treatments of combination implants make them microscopically retentive to bone. The surface is altered in a way that it can be machined, textured, and added with a coating. All in all, combination implant designs present a press-fit surgical approach like cylinder implants and a macroscopic implant design for occlusal loads (9).

2.1.2. Surgical approaches and prosthetic attachments

Three different surgical techniques utilized in two-piece implant systems include the one-stage approach, the two-stage surgical procedure, and immediate restoration.

In the two-stage approach, the implant body is positioned beneath the soft tissue, allowing for initial bone healing. During the first stage of the surgery, a cover screw is attached to the top of the implant to prevent bone, soft tissue, or debris from invading the abutment connection area during the healing phase. A secondary surgery follows with attaching an abutment or per-mucosal element after reflection of the soft tissues. The function of the per-mucosal extension is to extend the implant above the soft tissue and to facilitate the development of a per-mucosal seal around the implant.

Conversely, the one-stage surgical approach involves placing the implant body along with the per-mucosal element above the soft tissue until initial maturation of the bone has occurred. Another option could be choosing an implant body design with a cervical collar of sufficient height to be positioned supra-gingivally.

Placement of the implant body and the prosthetic abutment at a single surgery describes the immediate restoration approach. A commonly used transitional restoration is then placed within two weeks of the surgical procedure.

An attachment is a component of the dental implant that provides retention and support for a prosthesis or implant superstructure. A superstructure refers to a metal framework that connects to the implant abutment(s) and serves as a retentive element for a removable prosthesis or as the framework for a fixed prosthesis. Various options exist for abutment design and material selection.

Based on the method of retaining the prosthesis or superstructure to the abutment, three different types of abutments are classified. An abutment for screw retention includes a screw for securing the superstructure or prosthesis, while an abutment for cement retention utilizes cement for retention. Lastly, an abutment for attachment has an attachment device as a retentive element for a removable prosthesis incorporated.

Based on the axial relationship between the implant body and the abutment, abutments can also be differentiated as straight or angled (9).

2.1.3. Materials

Dental implants can be classified according to the materials used. The implants can be made of metal, ceramics, polymers, or carbon.

Metallic dental implants are made from metal and the most used metal nowadays is titanium. Stainless steel, Vitallium, and an alloy of cobalt chromium molybdenum can be utilized, too.

Ceramic material is used as a coat or sprayed layer on the implant surface to get a bioactive surface. Also, non-reactive ceramic materials can be employed.

Polymeric implants are made from PTFE and PMMA. However, these have been used only in conjunction with dental implants composed of other materials to assist in the distribution of stress, rather than being utilized independently.

Carbon implants consist of a mixture of carbon and stainless steel. They are more brittle and prone to fracturing when compared to dental implants made from alternative materials. Equally, they exhibit similar elasticity to the jawbone (10).

2.2. Implant planning

In order to plan dental implant treatment, accurate and comprehensive radiographic imaging is indicated. The implant team is responsible for evaluating each individual patient on which imaging modality must be used, and the final decision is made by reliable and practical data.

Conventional two-dimensional imaging techniques highlighted several disadvantages in implant dentistry in the past and therefore displayed high false-negative and false-positive images. Nowadays, three-dimensional systems are available on the dental market and serve as a crucial tool for clinicians in implant dentistry. Dental implant treatment planning cannot be imagined without computed tomography anymore. CT raises the level of particularized information available in the diagnosis, and planning of the treatment, surgical, and prosthetic phases of dental implant therapy.

Different phases are distinguished in dental implant treatment.

Phase 1 is called presurgical implant imaging and its objectives imply the needed surgical and prosthetic data to identify the quantity and quality of bone, proposed implant sites, determination of vital structures, prosthetic needs, and if a disease is present or absent.

Phase 2 or the surgical and intraoperative imaging phase includes the evaluation of the surgery sites during and after the surgical intervention, and achieving the proper position and orientation of the implants. Additionally, it is important to assess the healing and integration phase of the surgery, as well as the correct positioning of abutments and fabrication of the prosthesis in the final step.

Phase 3 or post-prosthetic imaging involves a post-prosthetic image that serves as a basis for future marginal bone level evaluation and component fit verification (11).

2.3. Osseointegration

Osseointegration is a histologic term that defines the relationship between bone and a dental implant. Under light microscopy, bone exhibits direct contact with the surface of the implant (8).

Today osseointegration has become a fundamental concept in the discipline of implantology and encompasses besides a microscopic level also a clinical state of rigid fixation (9).

Osseointegration is a critical biological process that serves as the foundation for modern dental implantology and is influenced by the selection of the implant material. This process enables the implant to integrate with the alveolar bone, thereby preventing bone disintegration and the loss of alveolar arch height. By modifying the surface of titanium implants to improve their biological properties, the principle of osseointegration is promoted.

Certain medications taken by patients can impact the success of implants as osseointegration might be affected (10).

2.4. Age restrictions

In considering the placement of an implant, it is essential to evaluate the patient's age. The age of the patient is a crucial factor when replacing a maxillary frontal tooth, particularly when dealing with congenital missing second incisors. The objective is to place the implant in an area with adequate bone to prevent future bone loss. However, there is a concern that the placement of an implant may affect growth and development, potentially leading to outcomes similar to those observed with ankylosed teeth. Unlike natural teeth, implants do not undergo eruption alongside neighboring teeth, which can result in displacement relative to adjacent teeth during the growth and development of the jaws. In the most severe cases, this may lead to soft tissue recession and the formation of a peri-implant pocket next to the implant.

Usually, age guidelines are more connected to the biological age of the patient than to the chronological age. Due to a slight permanent eruption of neighboring teeth after adolescence a fixed chronological age doesn't indicate to be a proper guideline. Orthodontic therapy rather achieves adequate space to prevent intrusion of a tooth, establishes incisor stability, and avoids relapse by stabilization with a retainer. It is common that the lateral incisor is shorter than the adjacent teeth. That's why the central incisor may be placed at an earlier age than a central incisor or canine. A shorter central incisor can pose a more apparent esthetic concern as neighboring teeth continue to shift more incisal due to growth and development. Furthermore, variations in the height position of lateral incisors are typically less visible to the observer when compared to central incisors (12).

Implant therapy should be delayed until adulthood if the patient is younger than 18 years (13).

Particularly, there is a general rule that states that implant placement in the anterior maxilla is delayed for females until at least 15 years of age and for males until 18 years of age (12).

This recommendation is due to the potential complications associated with the possible infra-position of the dental implant (13).

Assessing several other aspects that are indicative of completed growth is also crucial. Female patients should have reached menarche, whereas males should normally begin shaving if their fathers shave regularly. Children should be taller than their parents of the same sex. The size of the young patient is more critical than the age. One guideline stands that if the patient has not grown over three consecutive six-month periods, the dental implant can be placed. Others recommend using lateral cephalograms over two consecutive years with no detected changes (12).

2.5. Prosthodontic restoration

Creating the illusion of a natural crown on an implant abutment often requires additional prosthetic steps involving components with varied emergence profiles or custom tooth-colored abutments (14).

Before placing a permanent restoration, a provisional restoration is typically placed. The criteria for an acceptable provisional restoration include comfort, functionality, aesthetics, non-impingement, and longevity (15). It is recommended to use an acrylic provisional restoration with a progressive occlusal loading approach to enhance the bone-implant interface before placing the final restoration. This method involves careful design of the occlusion and gradual application of masticatory loads within the implant system (16).

Besides an implant-supported crown, there is also the option of a traditional FPD, a cantilever FPD, RPD, and an acid-etched resin-bonded fixed partial denture to replace a missing maxillary anterior single-tooth (12).

2.6. Aesthetics in the frontal region

Successful implant restoration is achieved when soft and hard tissue surrounding an implant is restored to an optimal architecture, meaning a good integration of the implant crown and soft tissue drape within the adjacent dentition. Especially anterior single-tooth replacement in the highly esthetic zone of the premaxilla presents a challenging treatment option for professionals and becomes even more demanding when dealing with an implant abutment. Endodontic failure, resorption, trauma, fracture, partial anodontia, and caries are shown to be common reasons for maxillary anterior single-tooth loss (12).

Implants are typically 5 mm or less in diameter and have a round cross-section, unlike the natural maxillary anterior tooth crown cervix which ranges from 4.5 to 7 mm in mesiodistal width and is not perfectly round. Specifically, natural central incisors and canines often exhibit a greater facio-palatal dimension at the CEJ compared to the mesiodistal dimension.

Bone loss tends to occur primarily in the facio-palatal dimension, necessitating wider implants to mimic the root of a tooth, which in turn requires extensive bone augmentation beyond current recommendations. Therefore, a smaller-diameter round dental implant is proposed, with an emphasis on achieving the cervical esthetics of a single implant crown that complements the round implant shape.

The space available mesiodistally, bone height relative to soft tissue drape, facio-palatal width, soft tissue characteristics, and position and size of adjacent maxillary anterior teeth all influence the treatment planning. Moreover, factors such as tissue biotype, implant crest module design, ideal implant size, and transitional restoration during healing are important considerations for achieving optimal outcomes in esthetic implant dentistry (14).

2.6.1. Color of teeth

Shade determination is defined as a visual perception within the visible spectrum of electromagnetic radiation.

In prosthetic dentistry, shade selection plays a crucial role during the treatment. The purpose of choosing the right color lies in personalizing the treatment and achieving successful results for the patient. Especially in expensive and time-consuming procedures, such as ceramic restorations, every effort must be made to ensure success in every detail, with particular emphasis on visual aesthetics.

The color of natural teeth is not the same in all areas. In the cervical part, the shade of the tooth is observed as more opaque and darker due to thicker dentin and a thinner enamel in that particular region. In the incisal part of the tooth, the tooth appears more translucent and brighter because of thinner dentin and thicker enamel.

Color matching presents to be subjective and can be influenced by conditions such as the light source, occlusal factors, background color, and the opacity and color of the tooth on which the crown is placed. The determination of the shade can also be manipulated by operator-related aspects such as age, gender, experience, and tiredness (17).

Today, various methods are accessible to define, evaluate, and verify tooth color. The available approaches include visual methods using dental shade guides, as well as digital methods with shade-taking devices, imaging systems, and color-matching software programs.

Sets of tooth color physical samples, or dental shade guides, are used to select the right color of teeth or restorations. In these visual methods, the physical samples are positioned close to the tooth in the same plane and incisal alignment is ensured. Then the shade that has the most similarity to the tooth shade and adjacent tooth or restoration is chosen for the fabrication of the new restoration. Additionally, shade tabs should be matched with both natural teeth and restorative materials. Consequently, manufacturers have created shade guides tailored to their restorative materials, considering the diverse optical properties of the materials (18).

Table 1. Standard commercial dental shade guides. Acquired from (18)

Shade guide name	Related material	Shade tabs number	Shade categories	Rationale	Shade selection steps	Manufacturer
VITA classical A1-D4	Ceramic	16	A (reddish-brownish) B (reddish-yellowish) C (grayish) D (reddish-gray)	Questionable	1 step: based on lightness, or 2 steps: based on a preselection of hue group, a shade tab is selected.	VITA Zahnfabrik H. Rauter GmbH & Co. KG, Bad Säckingen, Germany
VITA Toothguide 3D-Master	Ceramic	29 (including 26 tooth-shaded tabs and 3 tabs of VITA Bleached Shades: 0 M1, 0 M2 and 0 M3)	Lightness levels: 0,1,2,3,4,5 (light to dark) Chroma levels: 1, 1.5, 2, 2.5, 3 (low to high) Hue levels: M (neutral), L (yellow), R (red)	Normally-distributed shades accurately determined by color science	3 steps: selection of lightness, chroma, and hue, respectively	VITA Zahnfabrik H. Rauter GmbH & Co. KG, Bad Säckingen, Germany
VITA Linearguide 3D-Master	Ceramic	29 (the same tabs as VITA Toothguide 3D-Master with different arragement)	Lightness levels: 0,1,2,3,4,5 (light to dark) Chroma levels: 1, 1.5, 2, 2.5, 3 (low to high) Hue levels: M (neutral), L (yellow), R (red)	A VITA value guide 3D-Master and 5 VITA Chroma / Hue guides 3D-Master	2 steps: based on a preselection from the value guide 3D-Master, a selection is made from the Chroma/ Hue guide3D-Master.	VITA Zahnfabrik H. Rauter GmbH & Co. KG, Bad Säckingen, Germany
Chromascop	Ceramic	20	Group 100 for white, group 200 for yellow, group 300 for light brown, group 400 for gray, group 500 for dark brown	An arrangement of shade tabs in 5 groups of 4	2 steps: based on a preselection of the shade group, a shade tab is selected.	Ivoclar Vivadent AG, Schaan, Liechtenstein
Bioform IPN	Porcelain and plastic material (denture teeth)	24	Four groups of hue, 16 B shades from B51 to B93 corresponding to the VITA A-D shades and 8 Biofrom shades from B59 to B81	Based on the most popular shades for both denture teeth and porcelain materials	1 step: for value arrangement, 2 steps: based on hue/chroma arrangement	Dentsply Sirona, York, PA
Portrait IPN	Plastic material (denture teeth)	27	16 "P" shades from P1 to P34 corresponding to the VITA A-D shades, 8 shades from P59 to P81 according to the 'Base 8' Bioform shades, and 3 bleach shades (PW2, PW4, PW7)	Based on the VITA classical A1-D4, Bioform B59-B81, and bleached shades	1 step: for value arrangement, 2 steps: based on hue/chroma arrangement	Dentsply Sirona, York, PA
Bioblend IPN	Porcelain and plastic material (denture teeth)	12 (including central, lateral, and canine sets of shade tabs)	Bleached shades typified the three-tooth tabs of the Bioblend IPN Blend Selector	For imitation of natural decalcification and check lines	In harmonization with the patient's hair, eyes, and complexion	Dentsply Sirona, York, PA
Ceramco 3 Dentin	Ceramic	16	A (reddish-brownish) B (reddish-yellowish) C (grayish) D (reddish-grayish)	Pre-fired porcelain tabs based on VITA classical shade guide	Shade selection steps comparable to VITA classical shade guide	Dentsply Sirona, York, PA
Vintage Halo NCC	Ceramic	38	NCC Value Plus shade guide (14 shades), NCC Standard shade guide (16 shades), NCC Value Minus shade guide (8 shades), and Gumy indicator	Corrected to the 3D tooth color space; based on the red shift concept, the GUMYs available in three shades for gingiva (light, medium, dark)	The GUMYs are used with the tooth shade guide to counteract the color saturation of the gingiva and place the shade tab in the same surroundings.	Shofu Inc., Kyoto, Japan

Since 1990, a range of digital tools has been developed for dental shade selection. These instruments involve digital cameras, colorimeters, spectrophotometers, and intraoral scanners (18).

High-resolution optical cameras are commonly found in photographic devices and mobile phones. The latter can compete with traditional photo cameras because of their advanced optical systems. These cameras may feature a built-in flash or be used with separately purchased ring lights. Analyzing photographs taken with these cameras using appropriate software can also serve as a method for determining the right dental shade.

A dental CCM is a simple and low-price optical device that analyzes reflective light, collects data, converts these data to color parameters, and as a result specifies the shade of teeth (17).

A SPM is an instrument that performs full-spectrum colorimetric measurements and evaluates color by using only three filters: red, green, and blue color (18). It is known that SPM is more advanced than a CCM and offers the highest level of accuracy and precision when compared to other shade selection methods (17,18).

Intraoral scanners have been initially applied in digital impression-making. Nowadays, scanners are additionally equipped with a tool for dental shade measurement. This tool uses a high-resolution camera that estimates the appropriate tooth color with software after scanning the tooth with LED light. As a result, the restoration can be fabricated using the selected shade based on VITA shades and the digital impression (18).

3. CASE REPORT

V. B., a male patient, experienced a football-related injury that resulted in the prosthetic treatment of tooth 21. The trauma to his frontal left central incisor was induced by a collision with the head of his football teammate (Picture 2. and Picture 3.). The incident occurred in August in the year 2019 when the patient was 20 years old. Following the injury, an immediate X-ray revealed a horizontal fracture in the central portion of tooth 21 (Picture 4. and Picture 5.). Additionally, tooth 22 sustained minor trauma, resulting in an incisal edge fracture (Picture 3.). The prosthodontic treatment, which will be explained in detail below, involves several steps.

Picture 2. The photograph in the car captures the condition immediately following the football injury (23rd of August 2019).

(Image used with permission from the author, prof. dr. sc. Sonja Kraljević Šimunković, dr. med. dent., Department of mobile prosthodontics.)

Picture 3. Tooth 21 is visibly mobile, nearly dislodged from the alveolar socket, with evident bleeding and significant swelling of the upper lip. Minor incisal edge fracture of tooth 22 visible.

(Image used with permission from the author, prof. dr. sc. Sonja Kraljević Šimunković, dr. med. dent., Department of mobile prosthodontics.)

Picture 4. Radiograph illustrating teeth 12, 11, 21, and 22. An immediate X-ray image taken right after the incident shows a horizontal fracture in the middle of the tooth 21. Tooth 11 exhibits successful endodontic treatment completed before the trauma occurred.

(Image used with permission from the author, prof. dr. sc. Sonja Kraljević Šimunković, dr. med. dent., Department of mobile prosthodontics.)

Picture 5. Radiograph revealing teeth 21, 22, and 23. The radiographic image clearly depicts the horizontal fracture in the middle of tooth 21.

(Image used with permission from the author, prof. dr. sc. Sonja Kraljević Šimunković, dr. med. dent., Department of mobile prosthodontics.)

Picture 6. Radiograph displaying teeth 11, 12, 13, and 14. None of these teeth were affected by the trauma.

(Image used with permission from the author, prof. dr. sc. Sonja Kraljević Šimunković, dr. med. dent., Department of mobile prosthodontics.)

Initially, tooth 21 was extracted, followed by the immediate placement of a provisional restoration (Picture 7. and Picture 8.). In order to better accept the effect of tooth loss, the patient's own tooth 21 was used as a provisional after extraction. Moreover, the purpose of the bonded natural tooth pontic lies in protecting the extraction area and serving as an ovate pontic contact surface. Compared to an acrylic or composite tooth the natural tooth is the optimal pontic in terms of color, shape, size, alignment, and adhesion. For stabilization, a periodontal splint was placed on the palatal aspect of the tooth.

Subsequently, implant therapy was performed to replace tooth 21, followed by the placement of a crown on the implant site (Picture 9. to Picture 12.).

Picture 7. Extraction of the fractured tooth 21 after the trauma (24th of August 2019). Due to the condition of the bone immediate implantation after extraction was not possible.

(Image used with permission from the author, prof. dr. sc. Sonja Kraljević Šimunković, dr. med. dent., Department of mobile prosthodontics.)

Picture 8. Placement of the patient’s original tooth 21 as an immediate provisional after extraction. Typically, there is a noticeable change in color of tooth 21 after extraction.

(Image used with permission from the author, prof. dr. sc. Sonja Kraljević Šimunković, dr. med. dent., Department of mobile prosthodontics.)

Picture 9. Photograph showing a successfully placed dental implant after extraction of the fractured tooth 21 and raising and repositioning of a flap after implant placement (September 2019).

(Image used with permission from the author, prof. dr. sc. Sonja Kraljević Šimunković, dr. med. dent., Department of mobile prosthodontics.)

Picture 10. The provisional restoration after implant placement permits the patient to function normally in terms of speech, mastication, and psychological well-being.

(Image used with permission from the author, prof. dr. sc. Sonja Kraljević Šimunković, dr. med. dent., Department of mobile prosthodontics.)

Due to aesthetic reasons, a crown was placed on tooth 11, which had undergone endodontic treatment prior to the sports-related trauma. Furthermore, the fracture of the left lateral incisor was restored using composite material (Picture 11. and Picture 12.).

Picture 11. Image illustrating the completed crowns on the implant site (Emax crown) and on tooth 11 (metal-ceramic crown), which had undergone endodontic therapy prior to the trauma (04^{th} of January 2020).

(Image used with permission from the author, prof. dr. sc. Sonja Kraljević Šimunković, dr. med. dent., Department of mobile prosthodontics.)

Picture 12. Besides the placement of the two crowns on the central incisors, a composite restoration of the fractured incisal edge on tooth 22 was performed.

(Image used with permission from the author, prof. dr. sc. Sonja Kraljević Šimunković, dr. med. dent., Department of mobile prosthodontics.)

After a four-year follow-up, the patient came for a check-up, and a new photograph was taken. The outcomes presented were completely satisfactory (Picture 13.). The successful therapy described in this case report allows the young patient to continue his physical and psychological development without compromising his self-confidence during adulthood.

Picture 13. Image from the latest check-up, four years after treatment, showing satisfactory outcomes with the exception of a slightly noticeable gingival recession around crown 11 (January 2024).

(Image used with permission from the author, prof. dr. sc. Sonja Kraljević Šimunković, dr. med. dent., Department of mobile prosthodontics.)

4. DISCUSSION

The above-presented case report illustrates a situation where the age of the patient was on the borderline for dental implant therapy. However, the decision was made to proceed with the implant placement.

Implant dentistry is a controversial topic in growing patients whose maxillary and mandibular skeletal and dental growth is not completed. Both the maxilla and mandible undergo dynamic changes during childhood.

Due to the resorptive processes occurring at the nasal floor and the anterior surface of the maxilla, dental implants may unpredictably dislocate vertically and anteroposteriorly, and also there is a risk of implant loss. The majority of transversal growth in the maxilla occurs at the mid-palatal suture. Fixed implant structures that cross this suture can restrict the transverse growth of the maxilla as a consequence. In summary, implant therapy in the still-developing upper jaw should be avoided until early adulthood.

In the lower jaw, transversal skeletal or alveoli-dental changes are less pronounced compared to those in the maxilla. Growth changes in the posterior mandible primarily happen in late childhood and involve significant anteroposterior, vertical, and transverse development. Additionally, the lower jaw undergoes rotational growth, particularly affecting vertical changes. When multiple teeth are present, vertical growth plays an important role in increasing dental height which leads to compensatory anteroposterior adjustments in the dentition. Consequently, implants are likely to remain in an infra-occlusal position and may be displaced anteroposteriorly. Alveolar growth is relatively minimal in the absence of teeth in the anterior mandible. Most transversal growth of the lower jaw occurs early in childhood, with anteroposterior growth primarily in the posterior part of the mandible. Especially in children with severe hypodontia, the anterior mandible may be the most suitable site for implant placement.

Therefore, it is suggested to wait for active and dynamic growth to be finished to place implants in those patients. When considering placing implants in young patients the right time should be determined with the help of cephalographic radiographs, hand wrist radiographs, or the serial measure of the stature. Also, aspects such as the individual status of the existing dentition, esthetic aspects, the functional status of phonetics and mastication, as well as emotional and mental well-being should be taken into consideration. Most importantly, the child and the parents need to be compliant with implant therapy and its associated hygiene. Benefits and possible complications need to be clarified with the parents in advance if implant therapy is considered or favored in young patients before their skeletal growth and maturation are over.

On the other hand, to treat these patients immediately after traumatic tooth loss before skeletal and dental maturation a removable prosthesis might be the solution. The consequences of removable dentures are characterized by an increased residual alveolar resorption, increased caries risk, and periodontal issues (19).

Besides the placement of dental implants and removable dentures, alternative treatment options for missing upper anterior teeth involve a traditionally fixed bridge prosthesis, resin-bonded bridgework, and auto-transplantation of developing premolars (2,13).

FBP presents the most invasive option as crown preparations have been reported to require the removal of 63% to 72% of the total healthy tooth structure. Considering the size of the pulp chamber in young patients, there might be a need for endodontic therapy due to crown preparation.

In contrast, proper esthetics and function are achieved with RBFDP, a minimally invasive treatment alternative. All-ceramic RBFDP can be classified into four different designs in the anterior region. The most common and first design is a lingual retainer design which can be further divided into two types. Type I is a classical two-retainer design that is connected to both of the adjacent teeth. Type II describes a cantilever design with one lingual retainer connected to one of the bordering teeth. A modified version of the two lingual retainer design exists in the treatment option for two missing mandibular incisors. The other three designs, the laminate veneer retained design, the inlay-like retainer design, and the Carolina bridge design, are still not studied well in terms of clinical survival rates. Summarizing the success of RBFDP, it can be stated that the cantilever design presents with more success than type I of the first design. However, this needs to be proved more in detail in further studies (13).

Tooth-supported restorations, such as FBP and RBFDP, are especially indicated when it is not possible to place a dental implant directly to the edentulous region. Sometimes even complex surgical procedures like bone augmentation or connective tissue grafting might be suggested in patients lacking hard and soft tissues in the edentulous area prior to implant placement. Inadequate bone volume, particularly no adequate mesiodistal space, facial-palatal width, and bone height, as well as insufficient crown height and two to four adjacent teeth with mobility greater than +1, are local contraindications to the anterior single-tooth implant placement (12). In addition, financial limits and fear of the surgery are indicators for an alternative therapy. Hence, tooth-supported prostheses appear to be a good alternative treatment option in contrast to implant therapy (13).

5. CONCLUSION

The above-described and documented case report about the prosthetic therapy of a young patient after sports trauma to his teeth has shown that prosthetic treatment is a reasonable as well as effective answer to restoring aesthetics and dental function. It is extremely crucial for the dentist to timely approach the treatment of a young patient with an appropriate procedure to avoid psychological and physical consequences for a young patient. Furthermore, it is important to evaluate the right time for the placement of a dental implant in young patients. Not only growth but also prevention of bone resorption plays a huge role in the evaluation process. The loss of a tooth in a young person could not be treated better than with implant prosthetics. This particular case proves that dental implantology provides full masticatory function, speaking ability, and aesthetics in a young patient. Most importantly, a dental implant gives psychological satisfaction to the patient and extends life quality.

To minimize the risk of sports-related traumas to the teeth and face, it is advisable to wear protective equipment when playing sports activities that carry a high risk for facial injuries. Although sports traumas cannot be avoided with protected equipment, it can certainly decrease the severity of the trauma and its consequences.

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7. BIOGRAPHY

Sanja Mandić was born on November 15, 1998, in Bad Tölz, Bavaria, Germany.

She was raised in Bad Tölz and spent most of her life there.

In the year 2009, she completed primary school, followed by her high school education at the "Gabriel-von-Seidl Gymnasium" in Bad Tölz, graduating in the year 2017.

During her time in high school, she took part in the exchange program with the "Lake Brantley High School" in Orlando, Florida. Furthermore, she participated in the International Model United Nations Conference in Istanbul, Turkey, in 2015. In 2017, she also took part in the George Watson's College Model United Nations Conference in Edinburgh, Scotland.

Because of her passion for dental medicine and her love for her father's homeland, she enrolled in the first year of the School of Dental Medicine, "Dental Studies in English Language", at the University of Zagreb in the year 2017.

During her studies, she gained both theoretical and practical knowledge by completing several internships at various dental practices in Germany and Croatia.