



QUALITY IN SPORT

eISSN 2450-3118 · Open Access · Peer-reviewed

apcz.umk.pl/QS

Nicolaus Copernicus
University in Toruń



KOZAK, Adrianna, LUBIŃSKA, Alicja, DADOUSH, Hana, JUNCIEWICZ, Julian, CIAŻKOWSKA, Karolina, PACHCIŃSKA, Monika, BIEDEREK, Wiktoria, JANCZAK, Oliwia, LITWIN, Bartosz, and NOWAKOWSKA, Michalina. **Fractures and Failures of Dental Implants Associated with Sports-Related Trauma - Biomechanical Aspects and Prevention: A Narrative Review.** *Quality in Sport.* 2026;74:74967. <https://doi.org/10.12775/QS.2026.74.74967>

ARTICLE TIMELINE

Received: 04.08.2026. Revised: 26.08.2026. Accepted: 07.09.2026. Published: 18.09.2026.

The journal has been awarded 20 points in the parametric evaluation by the Polish Ministry of Higher Education and Science (Annex to the announcement of 05.01.2024, No. 32553). Unique Journal Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of Social Sciences).

Punkty Ministerialne z 2019 – aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych). © The Authors 2026.

OPEN ACCESS · CC BY-NC-SA 4.0 This article is published with open access under the License Open Journal Systems of Nicolaus Copernicus University in Toruń, Poland, and is distributed under the terms of the Creative Commons Attribution Non-commercial Share Alike License (<http://creativecommons.org/licenses/by-nc-sa/4.0/>), which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the work is properly cited. The authors declare no conflict of interest regarding the publication of this paper.

Fractures and Failures of Dental Implants Associated with Sports-Related Trauma

- Biomechanical Aspects and Prevention: A Narrative Review

1. Adrianna Kozak

Email: adrianna.kozak@stud.umed.lodz.pl

Medical University of Łódź

<https://orcid.org/0009-0002-7664-4112>

2. Alicja Lubińska

<http://orcid.org/0009-0001-2593-5908>

E-mail: lubinska.alicja26@gmail.com

Private practice, Szczecin, Poland

3. Hana Dadoush

<https://orcid.org/0009-0004-4578-5320>

Email: Dadoush.hania@gmail.com

Medical University of Łódź

4. Julian Junciewicz

J.m.junciewicz@gmail.com

<https://orcid.org/0009-0004-2579-8298>

Medical University of Łódź

5. Karolina Ciążkowska

Email:kciazkowska@outlook.com

<https://orcid.org/0009-0006-4823-4350>

Medical University of Lodz Departament of Orthodontics

6. Monika Pachcińska

<https://orcid.org/0009-0009-3656-109X>

E-mail: pachcinskam@gmail.com

Poznan University of Medical Sciences: Poznan, Greater Poland

7. Wiktoria Biederek

<https://orcid.org/0009-0008-4504-7116>

Email: wiktoria.biederek@umed.lodz.pl

Department of Angiology, Medical University of Lodz, Lodz, Poland

8. Oliwia Janczak

<https://orcid.org/0009-0000-0611-5261>

Private practices, Lodz, Poland

janczak.oliwia@gmail.com

9. Bartosz Litwin

Email:bartek.litwin99@gmail.com

<https://orcid.org/0009-0009-7727-0029>

Medical University of Lodz

10. Michalina Nowakowska

Private practice, Poznan, Poland

Email:michalina1n@gmail.com

<https://orcid.org/0009-0001-9753-3692>

Abstract

Background. Dental implants are one of the most predictable and widely accepted treatment option for the rehabilitation of edentulous patients. Implant fracture is one of the most severe mechanical complications and may result from excessive or repetitive mechanical loading, unfavorable biomechanical conditions, trauma, and peri-implant bone loss. Athletes, particularly those participating in contact and collision sports, are at increased risk of orofacial trauma.

Aim. The aim of this narrative review is to address a current clinical gap regarding dental implants fractures in the clinical group including athletes. Although implant fractures have been described as a rare but significant mechanical complication, the influence of participation in sports and increased functional demands on implant failure has not been yet sufficiently researched. The review aims to evaluate the information included in known literature on potential relation between athletic activity and implant-related complications, while discussing biomechanical and risk factors, treatment approaches and preventive measures.

Materials and Methods. A literature search was conducted using the PubMed/MEDLINE, Scopus, and Web of Science databases using keywords: “Dental implants”, “Implants fracture”, “Sports dentistry”, “Athletes dental trauma”

Results. The reviewed literature identified dental implant fracture as a multifactorial complication associated primarily with excessive or repetitive mechanical loading, unfavorable biomechanical conditions, material fatigue, trauma, and peri-implant bone loss. Management depended on the extent of implant damage and the condition of the surrounding tissues, ranging from removal of the fractured component to complete implant explantation. In athletes, sports-related orofacial trauma represents an additional potential risk to implant-supported restorations, while mouthguards remain an important preventive strategy.

Conclusions. Dental implant fractures in athletes remain an insufficiently studied clinical problem, particularly among individuals participating in high-risk contact and collision sports. Further research is needed to better define the incidence, mechanisms, and risk factors

associated with implant-related complications in these populations. Careful treatment planning, appropriate implant-prosthetic rehabilitation, and long-term follow-up are essential for athletes with dental implants. In addition, the use of properly fitted mouthguards should be strongly emphasized as an important preventive measure against sports-related orofacial trauma and potential damage to implant-supported restorations.

Keywords: dental implant fracture, dental implant failure, sports trauma, sports dentistry, contact sports fatigue fracture, mechanical complications

1.Introduction

Dental implants have become one of the most predictable and widely accepted treatment options for the replacement of missing teeth and the rehabilitation of partially and completely edentulous patients. The development of implant design, biomaterials, surface modifications, digital treatment planning, and surgical and prosthetic protocols has significantly improved clinical outcomes, resulting in high long-term survival rates and predictable functional rehabilitation (Goodacre et al., 2003; Buser et al., 2017). Implant-supported restorations have transformed contemporary dentistry by restoring masticatory function, aesthetics, phonetics, and patients' quality of life (Buser et al., 2017).

The long-term success of implant therapy is primarily based on osseointegration, defined as a direct structural and functional connection between living bone and the surface of a load-bearing implant (Brånemark et al., 1977; Albrektsson et al., 1981). Dental implants are alloplastic biomaterials, most commonly manufactured from commercially pure titanium or titanium alloys such as Ti-6Al-4V ELI, which are surgically inserted into the alveolar bone to support prosthetic restorations. Titanium remains the material of choice due to its excellent biocompatibility, corrosion resistance, favorable mechanical properties, and ability to establish a stable bone-implant interface (Albrektsson et al., 1981; Shemtov-Yona and Rittel, 2015). However, long-term implant success depends not only on osseointegration but also on the maintenance of healthy peri-implant tissues and favorable biomechanical conditions during function (Berglundh et al., 2018).

Despite their high predictability, dental implants may be associated with biological, mechanical, technical, and aesthetic complications. Biological complications include peri-implant mucositis and peri-implantitis, whereas mechanical and technical complications include screw loosening, screw fracture, abutment failure, prosthetic fracture, loss of retention, and implant body fracture (Goodacre et al., 2003; Esposito et al., 1999). Among these complications, implant fracture is considered one of the most severe mechanical failures because it often results in loss of implant function and may require surgical removal followed by additional rehabilitation procedures (Al Quran et al., 2009; Stoichkov and Kirov, 2018).

The development of implant fractures is considered a multifactorial process involving implant-related, prosthetic, patient-related, and biomechanical factors. Excessive occlusal loading, parafunctional habits such as bruxism, inadequate implant dimensions, unfavorable implant positioning, prosthetic misfit, peri-implant bone loss, and fatigue caused by repetitive cyclic loading have been identified as important contributors to implant fracture (Conrad et al., 2008; Stoichkov and Kirov, 2018; Sáenz-Ravello et al., 2018; Manfredini et al., 2024). Due to repeated mechanical stress, microscopic defects may accumulate within the implant structure, eventually leading to fatigue failure and fracture (Shemtov-Yona and Rittel, 2015; Capodiferro et al., 2006).

The increasing number of young and physically active patients undergoing implant therapy has introduced new challenges for implant dentistry. Athletes represent a population with increased exposure to traumatic events affecting the orofacial region. Sports-related dental injuries are particularly common in contact and collision sports, including rugby, hockey, martial arts, boxing, handball, and football, where direct facial impacts frequently occur (Müller et al., 2021; Kumamoto and Maeda, 2004; Saini, 2012; Black et al., 2017). Such trauma may compromise natural teeth, prosthetic restorations, and implant-supported rehabilitations, potentially affecting long-term treatment outcomes (Stübinger et al., 2004; Murri Dello Diago et al., 2021).

In addition to acute trauma, athletes may be exposed to repetitive mechanical loading associated with intensive physical activity. Increased functional demands, high muscle activity, and potential parafunctional habits such as clenching may contribute to additional biomechanical stress on implant-supported restorations. Although direct evidence linking sports participation with implant fracture remains limited, the combination of traumatic exposure and increased mechanical loading represents a clinically relevant consideration in implant treatment planning for athletes.

Therefore, successful implant rehabilitation in physically active individuals requires careful assessment of biomechanical risk factors, individualized treatment planning, appropriate implant selection, occlusal evaluation, and preventive strategies. The use of protective mouthguards, particularly in contact sports, may reduce the incidence and severity of sports-related orofacial injuries and should be considered as part of preventive care in athletes with implant-supported restorations (Green, 2017; Fernandes et al., 2019; Knapik et al., 2019; Abbott et al., 2024).

The aim of this narrative review is to summarize current knowledge regarding implant fractures in athletes, with particular emphasis on potential sports-related risk factors, mechanisms of failure, diagnosis, management, and preventive strategies.

Research Objective

The objective of this narrative review is to analyze current knowledge regarding dental implant fractures in athletes, with particular emphasis on sports-related risk factors, implant failure mechanisms, diagnostic approaches, management strategies and preventive measures.

Research Questions

The review addresses the following practical questions: (1) What are the main mechanisms and risk factors contributing to dental implant fractures? (2) How may sports-related factors, mainly facial trauma and increased mechanical loading, influence the risk of complications in athletes? (3) What preventive approaches may reduce the risk of implant fractures in physically active patients? (4) What are the current limitations and knowledge gaps regarding the topic?

2. Research materials and methods

2.1 Study design and literature search strategy

The study was conducted as a narrative review of the current literature regarding dental implant fractures in athletes. The review was designed to provide a summary of available evidence on the mechanisms, risk factors, management, prevention strategies associated with implant fractures. Due to the limited number of studies directly investigating implant fractures in athletes, relevant evidence from implantology, biomechanics and sport dentistry literature was included to provide a comprehensive overview of the topic.

A literature search was conducted using the PubMed/MEDLINE database. The search included publications related to dental implant fractures, implant complications, biomechanics, sports-related dental trauma, and preventive strategies. The following keywords and combinations of

terms were used: “dental implant fracture”, “implant fracture”, “mechanical complications of dental implants”, “implant failure”, “sports dentistry”, “sports-related dental trauma”, “orofacial trauma”, “athletes”, “mouthguards”, “occlusal overload”, and “bruxism”.

2.2.Data collection and qualities synthesis

Relevant data from selected publications were extracted and organized according to the main objectives of the review. The collected information included study characteristics, publication type, factors contributing to implant fracture, biomechanical mechanisms, sports-related risks, diagnostic approaches, treatment strategies, and preventive measures.

Due to the limited number of studies directly addressing implant fractures in athletes, a qualitative synthesis approach was applied. Findings from implantology, biomechanics, and sports dentistry literature were integrated to identify common risk factors, current clinical approaches, and existing knowledge gaps. The quality and clinical relevance of available evidence were considered during interpretation of the findings.

2.3. AI assistance

Artificial intelligence tools were used as assistive instruments for organizing the manuscript structure, improving academic English and supporting editorial consistency. The final selection of literature, interpretation of clinical content, verification of references and conclusions require human author review. AI tools were not used as a source of clinical evidence, did not replace professional judgment and did not generate original research data.

3.Research results

3.1.Dental implant fractures -mechanisms

Although dental implants are considered to be highly effective demonstrating high long term survival rates, implant therapy is not free from complications. These complications are generally classified as biological, including peri-implantitis, or mechanical, such as screw loosening, abutment fracture, implant body fracture. Among mechanical complications, implant body fracture is regarded as the most serious frequently requiring extraction of the implant and its supporting bone. Mechanical complications are strongly influenced by the magnitude and characteristics of functional loading. Occlusal forces transferred to the implant may generate internal stress within the implant structure contributing to its failure over time.

The type of prosthetic restoration supported by implants may modify the distribution and magnitude of transmitted forces, affecting the biomechanical behavior of the implant-restoration complex.

Similar to parafunctional habits, intense physical activity may represent an additional source of increased mechanical demand. Parafunctional habits, such as bruxism and clenching, may increase stress within the implant-prosthetic system and contribute to earlier development of mechanical complications (Goodacre et al., 2003; Esposito et al., 1999; Conrad et al., 2008; Stoichkov and Kirov, 2018; Manfredini et al., 2024).

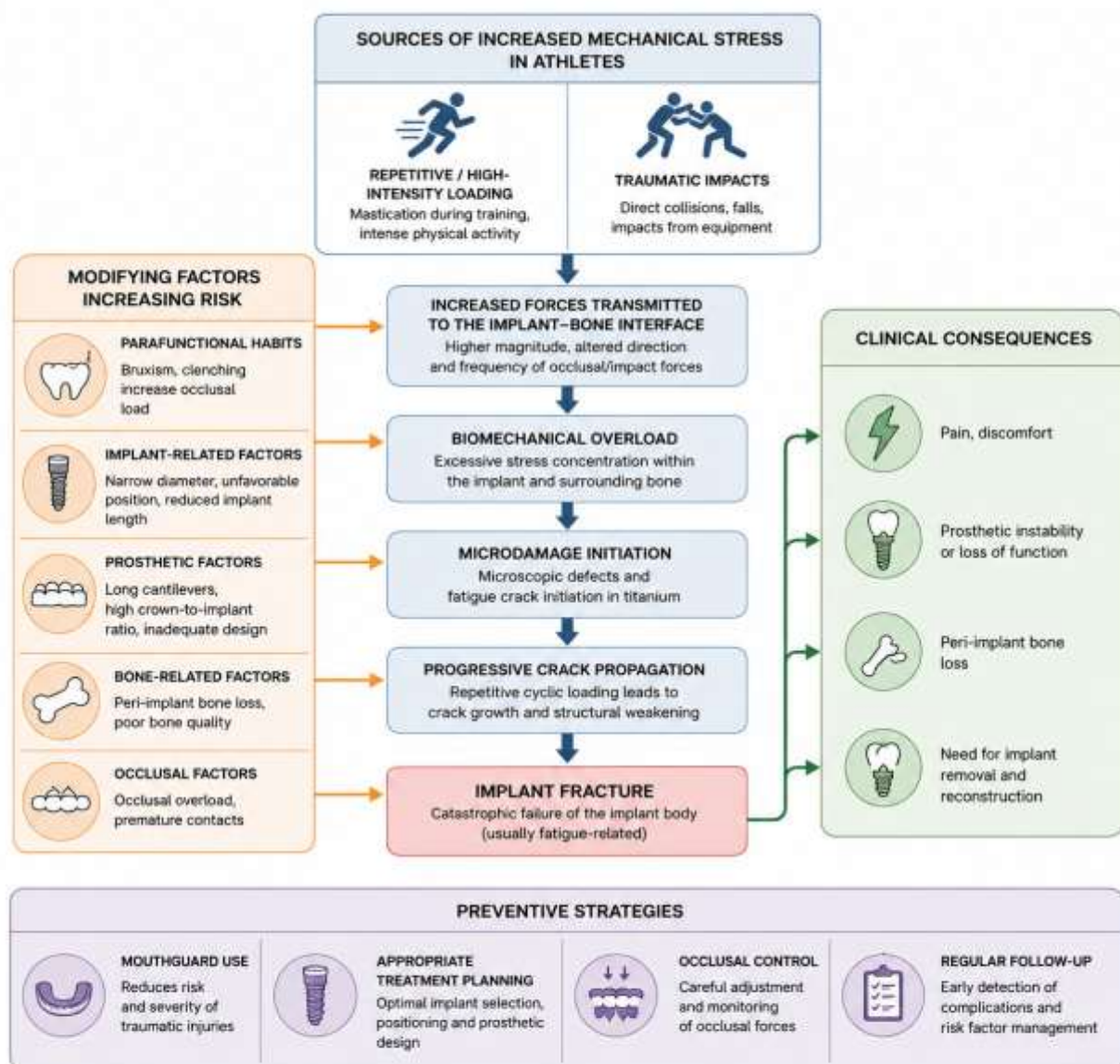


Figure 1. Schematic illustration of the potential relationship between sports-related factors and dental implant fracture.

Source: Author's own elaboration based on Conrad et al. (2008), Shemtov-Yona and Rittel (2015), Stoichkov and Kirov (2018), Manfredini et al. (2024), Müller et al. (2021), and Green (2017).

3.2.Failure Analysis in Implant Dentistry

Implant fracture is generally considered a fatigue-related phenomenon rather than the result of a single traumatic event. Repetitive cyclic loading generated during mastication induces microscopic defects within the titanium structure. These microcracks gradually propagate under continuous functional loading until the remaining cross-sectional area of the implant is no longer able to withstand occlusal forces, resulting in catastrophic fracture(Shemtov-Yona and Rittel, 2015; Capodiferro et al., 2006).

The development of fatigue failure is influenced by several biomechanical factors, including implant geometry, stress concentration, prosthetic design, and the amount of supporting peri-implant bone. Bone loss increases bending moments acting on the implant, whereas narrow-diameter implants exhibit reduced resistance to cyclic loading. Fractographic analysis using scanning electron microscopy has demonstrated characteristic fatigue striations and crack propagation patterns, confirming that most implant fractures develop progressively before complete mechanical failure(Stoichkov and Kirov, 2018; Sáenz-Ravello et al., 2018; Manfredini et al., 2024). Understanding the biomechanical mechanisms responsible for implant fracture is essential before discussing the potential influence of sports-related trauma and increased mechanical loading in physically active individuals.

3.4.Facial trauma and sport-related injuries

Sports activities, particularly those involving physical contact, represent an important risk factor for maxillofacial trauma. Athletes participating in disciplines such as combat sports, rugby, American football, hockey, basketball, and martial arts are exposed to repetitive or high-energy impacts that may affect the dentoalveolar structures and implant-supported restorations. Traumatic forces transmitted to the facial skeleton can result in implant-related complications, including peri-implant bone damage, prosthetic fractures, screw loosening, and, in severe cases, implant fracture. Although dental implants demonstrate high survival rates, they are not immune to mechanical complications, especially when subjected to excessive loading conditions exceeding their biomechanical tolerance(Müller et al., 2021; Kumamoto and Maeda, 2004; Black et al., 2017; Stübinger et al., 2004).

Contact sports are associated with a higher incidence of dental and maxillofacial injuries due to direct collisions, falls, and impacts from sports equipment. Unlike natural teeth, osseointegrated implants lack a periodontal ligament, which normally provides proprioception

and allows physiological shock absorption. Consequently, forces applied to implant-supported restorations are transferred more directly to the implant–bone interface. In athletes exposed to repeated trauma, this altered biomechanical response may increase the risk of mechanical complications, particularly when combined with unfavorable implant positioning, reduced bone support, or excessive occlusal forces(Tuna and Ozel, 2014; Shemtov-Yona and Rittel, 2015).

The development of implant fractures is strongly related to the magnitude, direction, and frequency of mechanical forces acting on the implant system. During sports activity, implants may be exposed not only to acute traumatic forces but also to repetitive cyclic loading. High-impact movements, sudden muscle contractions, and accidental collisions may generate bending moments and tensile stresses that contribute to fatigue-related damage of implant components. Implant fracture is generally considered a late mechanical complication associated with repeated stress accumulation, where microscopic structural defects may progressively develop until complete failure occurs. The risk may be increased in cases involving narrow-diameter implants, excessive cantilevers, unfavorable crown-to-implant ratios, or insufficient prosthetic design(Conrad et al., 2008; Stoichkov and Kirov, 2018; Sáenz-Ravello et al., 2018; Manfredini et al., 2024).

Parafunctional activity, including bruxism and increased masticatory muscle activation during physical effort, may represent an additional factor influencing implant biomechanics. Studies investigating exercise-induced jaw clenching suggest that high-intensity physical performance can be associated with increased activation of the masticatory muscles, potentially generating forces greater than those observed during normal function. In patients with dental implants, prolonged exposure to excessive occlusal forces may contribute to mechanical complications such as screw loosening, prosthetic fracture, and implant fatigue failure. However, the direct relationship between sports-related bruxism and implant fracture remains insufficiently investigated and requires further clinical research.

The increased risk of implant complications among athletes is likely multifactorial and results from the interaction between biological, mechanical, and behavioral factors. Repeated trauma, excessive functional loading, parafunctional habits, and inadequate protection during sports activities may negatively influence implant stability and prosthetic integrity. Additionally, early exposure to excessive mechanical loading may theoretically compromise implant healing. Therefore, implant rehabilitation in physically active individuals requires careful consideration of sport-specific risks, biomechanical conditions, and individualized preventive strategies(Müller et al., 2021; Shemtov-Yona and Rittel, 2015; Manfredini et al., 2024).

Diagnosis and management of implant fractures

Diagnosis of implant fracture

The diagnosis of dental implant fracture requires a comprehensive clinical and radiographic evaluation. Clinical signs may include pain, mobility of the prosthetic restoration or implant component, sudden loss of function, changes in occlusion, or prosthetic instability. Radiographic examination is essential to assess the location and extent of the fracture, the condition of surrounding bone tissue, and the presence of associated complications such as peri-implant bone loss. Differential diagnosis should include other mechanical complications, such as abutment screw fracture, prosthetic fracture, or loosening of implant components, as these conditions may require different treatment approaches (Esposito et al., 1999; Goodacre et al., 2003).

Treatment planning

Management of implant fractures should be based on identification of the underlying cause and evaluation of factors contributing to mechanical failure. Important considerations include implant position, implant diameter, prosthetic design, occlusal loading, bone support, and the presence of parafunctional habits such as bruxism. Before selecting a treatment strategy, clinicians should determine whether the complication affects only the prosthetic components or involves fracture of the implant fixture itself. While some mechanical complications may be managed by repair or replacement of prosthetic components, true implant body fracture usually requires surgical intervention (Stoichkov and Kirov, 2018; Manfredini et al., 2024).

Treatment options

The management of implant fracture depends on the location of the fracture, remaining bone support, and the possibility of restoring function. In cases involving fractured prosthetic screws or abutments, conservative approaches such as retrieval of the fractured component and replacement may be possible. However, when the implant fixture itself is fractured, removal is generally considered the preferred treatment option because predictable repair of the implant body is not currently available. Alternative approaches may include removal of only the coronal fractured segment while maintaining the apical portion if adequate stability and bone conditions are present; however, this approach requires careful radiographic and clinical assessment (Al Quran et al., 2009; Mendonça et al., 2009; Jin et al., 2017).

Implant removal

Implant removal may be necessary in cases of implant body fracture, severe peri-implant bone loss, infection, or inability to maintain the prosthetic restoration. Several explantation techniques have been described, including reverse torque, trephines, burs, piezosurgery, and other minimally invasive approaches. The preferred method aims to remove the failed implant while preserving as much surrounding bone as possible to facilitate future rehabilitation. Studies evaluating explantation techniques suggest that conservative removal methods, particularly reverse torque, may reduce damage to the surrounding tissues, although the choice of technique depends on individual clinical conditions(Masaki et al., 2024; Roy et al., 2020).

Post fracture reimplantation

Following implant removal, replacement with a new implant may be considered after adequate assessment of the implant site. The timing of reimplantation depends on factors such as the presence of infection, residual bone volume, defect morphology, and primary stability achievable during placement. In cases of implant fracture associated with excessive mechanical loading, modifications of the treatment plan may be required, including the use of wider implants, increasing the number of implants supporting *the restoration*, improving prosthetic design, or addressing parafunctional habits. However, evidence regarding optimal management after implant fracture remains limited, and available studies are mainly based on clinical reports and small patient groups(Talebi Ardakani et al., 2023; Roy et al., 2020; Masaki et al., 2024).

Prevention

The use of mouthguards is one of the most effective preventive strategies in sports dentistry. Mouthguards reduce the risk and severity of sports-related dentofacial injuries by absorbing and distributing impact forces. Although direct evidence regarding prevention of implant fracture is lacking, their ability to reduce facial trauma may be particularly relevant in athletes with implant-supported restorations(Green, 2017; Fernandes et al., 2019; Knapik et al., 2019; Abbott et al., 2024).

Appropriate treatment planning is essential for minimizing the risk of implant-related mechanical complications. Implant selection should consider patient-specific factors, including anatomical conditions, occlusal forces, type of prosthetic restoration, and functional demands. In athletes, additional consideration should be given to the type and intensity of sport, probability of facial trauma, and potential exposure to excessive mechanical loading. Selection of an appropriate implant diameter and length, optimal three-dimensional positioning, and

adequate prosthetic support may contribute to improved biomechanical stability and reduced risk of implant fracture(Conrad et al., 2008; Manfredini et al., 2024).

Occlusal overload is considered an important factor contributing to mechanical complications, including implant fracture. Careful occlusal adjustment and monitoring are therefore essential, especially in patients exposed to increased functional loading(Conrad et al., 2008; Stoichkov and Kirov, 2018).

Regular maintenance and follow-up visits allow early detection of biological and mechanical complications, including screw loosening, prosthetic instability, and excessive occlusal loading, potentially preventing progression to implant fracture(Goodacre et al., 2003; Esposito et al., 1999).

4.Discussion

Current evidence indicates that dental implant fracture is a multifactorial complication associated with biomechanical overload, implant design, prosthetic factors, and patient-related conditions such as parafunctional habits(Manfredini et al., 2024; Stoichkov and Kirov, 2018).However, most available studies focus on general implant populations, and evidence specifically regarding athletes remains limited.

Although contact sports are associated with an increased risk of dentofacial trauma, the direct relationship between sports participation and implant fracture has not been clearly established. The possible increased risk in athletes is mainly based on biomechanical considerations, including repetitive loading, traumatic forces, and increased functional demands(Müller et al., 2021; Shemtov-Yona and Rittel, 2015).

The main limitations of current literature include the low incidence of implant fractures, predominance of retrospective studies and case reports, and lack of sport-specific clinical data. Further prospective studies are needed to identify risk factors and develop preventive protocols for athletes with dental implants(Manfredini et al., 2024).

5. Conclusion

Dental implant fracture is a rare but significant mechanical complication that may compromise implant rehabilitation. Although athletes may be exposed to higher mechanical and traumatic demands, current evidence directly linking sports activity with implant fracture remains insufficient(Manfredini et al., 2024; Müller et al., 2021)

Individualized treatment planning, occlusal control, protective measures, and regular follow-up may help reduce the risk of complications. Further research is required to establish evidence-based guidelines for implant management in athletes (Green, 2017; Abbott et al., 2024).

AI Usage

Artificial intelligence (AI) tools were used to assist with the linguistic and syntactic revision of the English language, as well as to support the identification and retrieval of potentially relevant scientific literature indexed in PubMed.

References

1. Al Quran FA, Rashan BA, Al-Dwairi ZN. Management of dental implant fractures. A case history. *J Oral Implantol*. 2009;35(4):210–214. PMID: 19813428. DOI: 10.1563/1548-1336-35.4.210.
2. Müller KE, et al. Sport and Dental Traumatology: Surgical Solutions and Prevention. *Medicina (Kaunas)*. 2021;57(4):318., PMID: 33806915, DOI: 10.3390/dj9030033
3. Stoichkov B, Kirov D. Analysis of the causes of dental implant fracture: A retrospective clinical study. *Quintessence Int*. 2018;49(5):375-382. PMID: 29435519
4. Manfredini M, Poli PP, Giboli L, Beretta M, Maiorana C, Pellegrini M. Clinical Factors on Dental Implant Fractures: A Systematic Review. *Dent J (Basel)*. 2024;12(7):200. doi:10.3390/dj12070200. PMID: 39056987.
5. Conrad HJ, Schulte JK, Vallee MC. Fractures related to occlusal overload with single posterior implants: a clinical report. *J Prosthet Dent*. 2008;99(2):93-100. PMID: 18395533
6. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JYK. Clinical complications with implants and implant prostheses. *J Prosthet Dent*. 2003;90(2):121-132. PMID:12886205
7. Esposito M, Hirsch JM, Lekholm U, Thomsen P. Differential diagnosis and treatment strategies for biologic and technical complications in implant dentistry. *Int J Oral Maxillofac Implants*. 1999;14(4):473-490. PMID: 10453661
8. Masaki C, Kondo Y, Tomoeda K, Nodai T, Munemasa T, Mukaibo T, Hosokawa R. Treatment strategies for dental implant removal: A literature review. *Jpn Dent Sci Rev*. 2024;60:120–127. doi:10.1016/j.jdsr.2024.01.002. PMID: 39444488.
9. Roy M, Loutan L, Garavaglia G, Hashim D. Removal of osseointegrated dental implants: a systematic review of explantation techniques. *Clin Oral Investig*. 2020;24(1):47–60. doi:10.1007/s00784-019-03127-0. PMID: 31729576

10. Talebi Ardakani M, Amid R, Moscowchi A. Explantation Site Management: A Decision Algorithm for Re-Implantation. *Int J Periodontics Restorative Dent*. 2023;(7)–s35. doi:10.11607/prd.6287. PMID: 37471152.
11. Murri Dello Diago A, Apponi R, Colombini V, Mordini L, Ideo F. Complex Implant-Prosthetic Rehabilitation Following Sports Trauma with 14 Years of Follow-Up: Case Report. *Dent J (Basel)*. 2021;9(1):6. PMID: 33435430. DOI: 10.3390/dj9010006.
12. Stübinger S, Hodel Y, Filippi A. Trauma to anterior implants. *Dent Traumatol*. 2004;20(3):169–171. PMID: 15144449
13. Scott J, Burke FJ, Watts DC. A review of dental injuries and the use of mouthguards in contact team sports. *Br Dent J*. 1994;176(8):310–314. PMID: 7910469. DOI: 10.1038/sj.bdj.4808433.
14. Green JIJ. The Role of Mouthguards in Preventing and Reducing Sports-related Trauma. *Prim Dent J*. 2017;6(2):27–34. PMID: 28668098. DOI: 10.1308/205016817821281738.
15. Fernandes LM, Cordeiro Neto JC, Lima TFR, et al. The use of mouthguards and prevalence of dento-alveolar trauma among athletes: A systematic review and meta-analysis. *Dent Traumatol*. 2019;35(1):54–72. PMID: 30222244. DOI: 10.1111/edt.12441.
16. Knapik JJ, Hoedebecke BL, Rogers GG, Sharp MA, Marshall SW. Effectiveness of Mouthguards for the Prevention of Orofacial Injuries and Concussions in Sports: Systematic Review and Meta-Analysis. *Sports Med*. 2019;49(8):1217–1232. PMID: 31148073. DOI: 10.1007/s40279-019-01121-w.
17. Abbott PV, Tewari N, O'Connell AC, et al. The International Association of Dental Traumatology (IADT) and the Academy for Sports Dentistry (ASD) guidelines for prevention of traumatic dental injuries: Part 3: Mouthguards for the prevention of dental and oral trauma. *Dent Traumatol*. 2024;40 Suppl 1:7–9. PMID: 38363704. DOI: 10.1111/edt.12925.
18. Cao R, Zhang X, Xu Y, et al. Influence of wearing mouthguards on performance among athletes: A systematic review. *J Sci Med Sport*. 2023;26(9):493–503. PMID: 37524627. DOI: 10.1016/j.jsams.2023.07.006
19. Kumamoto DP, Maeda Y. A literature review of sports-related orofacial trauma. *Gen Dent*. 2004;52(3):270–280. PMID: 15206262.
20. Saini R. Sports dentistry. *J Pharm Bioallied Sci*. 2012;4(Suppl 2)–S322. doi:10.4103/0975-7406.100282. PMID: 22639498.

21. Tuna EB, Ozel E. Factors affecting sports-related orofacial injuries and the importance of mouthguards. *Sports Med.* 2014;44(6):777–783. doi:10.1007/s40279-014-0167-9. PMID: 24647854.
22. Black AM, Patton DA, Eliason PH, Emery CA. Prevention of Sport-related Facial Injuries. *Clin Sports Med.* 2017;36(2):257–278. doi:10.1016/j.csm.2016.11.002. PMID: 28314416.
23. Tewari N, Johnson RM, Mathur VP, Rahul M, Goel S, Ritwik P, Bansal K, Atif M. Global status of knowledge for prevention and emergency management of traumatic dental injuries in sports persons and coaches: A systematic review. *Dent Traumatol.* 2021;37(2):196–207. doi:10.1111/edt.12629. PMID: 33220152.
24. Stanbouly D, et al. Prevalence of Dentofacial Injuries and Concussions Among College Athletes and Their Perceptions of Mouthguards. *J Craniofac Surg.* 2021. PMID: 33710051.
25. Shemtov-Yona K, Rittel D. An Overview of the Mechanical Integrity of Dental Implants. *Biomed Res Int.* 2015;2015:547384. doi:10.1155/2015/547384. PMID: 26583117.
26. Capodiferro S, Favia G, Scivetti M, De Frenza G, Grassi R. Clinical management and microscopic characterisation of fatigue-induced failure of a dental implant. *Head Face Med.* 2006;2:18. PMID: 16792797.
27. Sáenz-Ravello G, et al. Factors influencing the fracture of dental implants. *Clin Oral Implants Res.* 2018. PMID: 29210188.
28. Mendonça G, Mendonça DBS, Fernandes-Neto AJ, Neves FD. Management of fractured dental implants: a case report. *Implant Dent.* 2009;18(1):10–16. doi:10.1097/ID.0b013e318192cafe. PMID: 19212233.
29. Jin SY, Kim SG, Oh JS, You JS, Jeong MA. Incidence and management of fractured dental implants: Case reports. *Implant Dent.* 2017;26:802–806. doi:10.1097/ID.0000000000000653. PMID: 28846561.
30. Brånemark PI, Hansson BO, Adell R, Breine U, Lindström J, Hallén O, Öhman A. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. *Scand J Plast Reconstr Surg Suppl.* 1977;16:1–132, PMID: 356184
31. Albrektsson T, Brånemark PI, Hansson HA, Lindström J. Osseointegrated titanium implants: requirements for ensuring a long-lasting, direct bone-to-implant anchorage in man. *Acta Orthop Scand.* 1981;52(2):155–170, PMID: 7240134

32. Berglundh T, Armitage G, Araujo MG, et al. Peri-implant diseases and conditions: Consensus report of workgroup 4 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. *J Clin Periodontol*. 2018;45(Suppl 20):S286–S291. PMID: 29926491
33. Buser D, Sennerby L, De Bruyn H. Modern implant dentistry based on osseointegration: 50 years of progress, current trends and open questions. *Periodontol 2000*. 2017;73(1):7–21, PMID: 28000276