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Cracked Tooth Syndrome Review

Mohammed Hamoudi Alsunboli[*a] , Salah M. Ibrahim[b]

[a,b]*college of dentistry , Al-Bayan University, Baghdad , Iraq,School of Dentistry, Kufa University, Iraq*
[a]*Email:m.hamoudi@albayan.edu.iq*
[b]*Email:salahbrahi1@gmail.com*

Abstract

Review Objective: The treatment of fractured tooth syndrome (CTS) is extremely challenging, primarily because it requires precise pre-restorative diagnosis and decision-making. This paper examines treatment methods for teeth affected by CTS and proposes a pertinent clinical decision tree.

Recent advancements have revealed that CTS is characterized by the occurrence of incomplete fractures in the original crowns of teeth.

The choice of preparation method and direct or indirect restorative procedures significantly impacts the long-term outlook for the tooth. Nevertheless, the complex causes, intricate diagnosis, and subjective choices regarding preparation provide difficulties in therapeutic care. Therefore, an informed decision tree's guidance becomes crucial. This decision tree should give primary importance to the logical preservation of tooth structure, the optimization of preparatory processes, and the careful assessment of restorative implications and choices. The diagnosis and choices made before restoring the tooth have a significant impact on the complex process of caring for cracked tooth syndrome (CTS). This review examines treatment techniques for teeth impacted by CTS and presents a relevant clinical decision tree.

Conclusion: Tackling the reparative needs of CTS requires a methodical approach. Implementing an informative and universally applicable decision tree can greatly improve daily clinical practice.

Keywords: Crack; Fracture; Hopeless tooth; cracked tooth syndrome; Filling.

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* Corresponding author.

1.Introduction

This study examines fractured tooth syndrome, a condition characterized by a range of symptoms that arise from tooth fractures. This study provides a thorough analysis of the literature on cracked tooth syndrome, focusing on four main aspects: the causes, diagnosis, treatment, and prevention, which all contribute to a comprehensive comprehension of the subject matter. The article starts by examining odontiatrogenic factors and then delves into noniatrogenic influences that contribute to cracked tooth syndrome. These variables encompass inadequate root canal therapy, incorrect restorative methods, and factors related to development and function. This study specifically examines fractured tooth syndrome, a condition characterized by a range of symptoms that arise from tooth fractures. This study offers a complete examination of the literature on cracked tooth syndrome, with a specific emphasis on four key elements: etiology, diagnosis, therapy, and prevention. These components collectively contribute to a thorough understanding of the problem. The essay initially explores odontiatrogenic causes and subsequently explores noniatrogenic elements that contribute to cracked tooth syndrome. The influences encompass poor root canal therapy, faulty restorative methods, and developmental and functional elements [1, 2]. Bacterial toxins have the ability to enter the pulp chamber, causing pain and eventually leading to the death of the pulp tissue. Possible causes may include parafunctional habits include bruxism, clenching, tooth wear patterns like the attrition and abrasion, deep fissures, significant fluctuations in intraoral temperature, and eating behaviors. Iatrogenic factors, including inadequate cavity design, improper selection of restoration materials, and a lack of caution in handling endodontic instruments, might exacerbate the condition [1,4].

Cameron first used the term "cracked tooth syndrome" (CTS) to describe the partial fracture of the visible portion of a natural tooth in 1964 [5]. However, researchers have used many terms to refer to incomplete dental fractures, including greenstick fractures, hairline fractures, cracked cusp syndrome, incomplete vertical tooth fractures, and fractured tooth difficulties [6]. Cracked tooth syndrome (CTS) commonly occurs due to a fractured tooth, leading to patients exhibiting a variety of signs and symptoms that might vary in intensity. Nevertheless, sensitivity is not always present, and when it does, exposure to cold stimuli and increased bite force can sometimes make it worse. Although some researchers have proposed that CTS predominantly impacts vital teeth, it can also manifest in nonvital teeth. The lower second molars, lower first molars, upper premolars, and second molars are the teeth most commonly affected by the condition. Instances of carpal tunnel syndrome (CTS) are also common in incisors after orthodontic debonding operations and in patients with bruxism. This illness is more common among male patients between the ages of 40 and 50. CTS can manifest in both natural teeth and those that have been restored with either direct or indirect methods. Crack lines usually extend vertically in a mesiodistal orientation [5].

Vertical crack lines that continue to the root are frequently recorded, whereas horizontal and horizontal-vertical crack lines are infrequently reported [7,8]. Although there have been many studies on the causes, occurrence, symptoms, treatment methods, and results of fractured teeth, more research is needed because their behavior is difficult to anticipate. In specific situations, minimally invasive dentistry protocols for cracked tooth syndrome (CTS) may inadvertently lead to total tooth loss, underscoring the importance of early diagnosis and appropriate treatment [5,9,10]. However, crack lines are often challenging to detect radiographically and may not be readily apparent upon visual inspection, necessitating careful clinical examination and experienced judgment in prognosis and treatment planning. Techniques such as magnification during clinical examination using a dental operating

microscope or dental loupes, transillumination, and staining of dental tissues following restoration removal can aid in crack line identification [8]. Accurate determination of crack location, depth, and extension is crucial for selecting and implementing appropriate restorative protocols, thereby limiting fracture propagation and associated pulpal complications [9,10]. The American Association of Endodontists (AAE) has created a categorization system that provides a practical and uniform method for evaluating prognosis. This system takes into account various parameters, including the extent of involvement of marginal ridges, dental pulp, and pulpal floor [11]. Teeth that have vertical fractures that extend to depths that cannot be reached for repair with gingivoplasty or alveoplasty are typically thought to be beyond repair. In addition, the World Dental Federation (FDI) has implemented a different and more comprehensive categorization for CTS, with the goal of providing clearer instructions for dentists. The taxonomy consists of six sections, which define dental tissues such as enamel, dentin, pulp, and periodontium. This framework provides a thorough basis for clinical comprehension [12]. This analysis primarily examines restorative therapies for teeth impacted by CTS, with techniques differing depending on the location and depth of the fracture (4,5). The American Association of Endodontists has developed a classification system for Carpal Tunnel Syndrome (CTS). 1. Craze line 2. ractured cusp 3.Cracked tooth 4.Split tooth 5. vertical root fracture.

Table 1

Table 1 American Association of Endodontists classification of CTS [9]

Classification	Originate	Direction	Symptoms	Pulp status	Prognosis
Craze line	Crown	Variable	None	Vital	Excellent
Fractured cusp	Crown	Mesiodistal and or buccal-lingual	Mild and generally, only to biting and cold	Usually vital	Good
Cracked tooth	Crown with/without root	Mesiodistal often central	Acute pain on biting Occasionally sharp pain to cold	Variable	Questionable: dependent on depth and extent of the crack
Split tooth	Crown with root	Mesiodistal	Marked pain on chewing	Often root-canal treatment	Poor unless crack
Vertical root fracture	Roots	Buccal-lingual	Vague pain similar to periodontal disease	Mainly root-canal treatment needed	treatment needed

1.1 Management of CTS Through Restoration

An effective tool for planning therapeutic treatment was the decision tree, which was previously used to describe the CTS management process. This decision tree includes three fundamental components: The three key factors to consider are: (1) careful preservation of tooth structure; (2) optimal preparation techniques; and (3) thoughtful evaluation of restorative choices [13].

1.2 Retention of tooth Structure Judiciously

When considering the retention of tooth structure, it is imperative to first assess the restorative condition of the tooth. A tooth with a restoration that could potentially increase the risk of fracture is categorized as "heavily restored," while those without such restorations are deemed "minimally restored" [13]. However, this classification process is intricate, influenced by multiple factors, and often subjective in clinical practice. The true scenario unfolds post-preparation, involving complete removal of existing restorations and enamel tissue lacking dentin support. Diagnosing a crack that shows symptoms is relatively easy, but when there are cracks that don't show any symptoms, it is important to consider several factors. These factors include the number and size of any remaining cusps, the shape and depth of the cavity that was prepared, the type and properties of the materials used for restoration, the technique used for restoration, the position of the tooth, the functional and potentially harmful loads on the tooth, and the amount of support the tooth has from the surrounding periodontal tissues [13,14]. Furthermore, numerous additional factors related to both dentists and patients must be taken into account. Beyond assessing the restorative condition of the tooth, it is crucial to determine whether cracks should be retained or removed. Dental cracks commonly have the ability to spread, and if they reach the mouth, the buildup of bacteria-filled dental plaque is unavoidable, which can potentially result in periodontal and/or pulpal diseases. Therefore, it is a frequently used clinical method to intentionally introduce cracks within the preparation. Nevertheless, this method is frequently inefficient, especially when there are vertical fissures or when the tooth has minimal or no restoration [13]. Furthermore, in situations where there is no apparent endpoint, it is typically not feasible to ascertain if a crack has been entirely eliminated, and tiny further cracks are hardly discernible [15]. Unwarranted loss of tooth tissue, particularly in biomechanically important cervical locations, can worsen the prognosis [13, 16]. Furthermore, when assessing the long-term bonding strength, enamel tissue is more advantageous than dentin when it comes to the placement of the restorative margin. This highlights the importance of carefully evaluating whether crack clearance is necessary [17]. Diagnosing a crack that shows symptoms is relatively easy, but when there are cracks that don't show any symptoms, it is important to consider different factors. These factors include the number and size of the cracks, the shape and depth of the cavity, the type and properties of the materials used for restoration, the technique used for restoration, the position of the tooth, the functional and potentially harmful loads on the tooth, and the amount of support from the surrounding gums.

Finally, an evaluation of cusp coverage is necessary. Research has firmly demonstrated that providing complete coverage of the damaged cusp or cusps improves the ability to withstand fractures by changing the direction of the force applied during biting (mostly from pulling stress to more supportive pushing stress) [18]. As a result, it is possible to achieve the necessary area for restoration by either increasing the occlusal depth of the preparation or invading the tooth [13]. When evaluating the lifespan of a clinical procedure, it is consistently more advantageous to prioritize the preservation of enamel tissue over dentin tissue [9]. However, while dealing with cases of CTS, it is generally wiser to adopt the idea of "preparation for prevention" rather than rigidly following the concept of "minimally invasive preparation." In the case of "minimally restored" teeth, where the afflicted cusps are present and the marginal ridges are intact and supported by dentin, there is no need for cusp reduction [13].

On the other hand, teeth that have undergone extensive restoration are more likely to bend at the pointed parts under increasing pulling force during use and are at risk of breaking over time [18]. Therefore, it is necessary to

decrease and completely cover the problematic cusps of severely repaired teeth after suitable preparation. Usually, slender cusp tips are lost when reducing the cusps. Enamel tissues that do not have dentin support, as well as enamel tissues with fissures that have dentin support, need to be included in the preparation [13]. Nevertheless, operators must be cautious when it comes to the depth of preparation and the equilibrium between increased thickness of restorative material in such situations [19]. To minimize the possibility of cusp fracture, it is advisable to eliminate any interactions with the retaining cusps during both dynamic and static occlusions. This will transfer the potential mode of failure from the tooth to the restoration. To achieve an optimal balance between force distribution and tooth structure maintenance, it is recommended to decrease the cusps by a range of 1.5 to 2 mm [13]. The reduction should be constantly applied to the fracture until dentin support is attained. To eliminate cracks, it is advisable to employ fissures or diamond burs. Water cooling is compatible with medium-circular or tapered-fine burs. The residual cracks can be verified by employing methylene blue dye [20]. Methylene blue, with its flocculent properties and tendency to collect, can be used to assess the magnitude of the fracture [21]. Cracks can be examined in detail by using either an operational microscope with a magnification of 6-8 or higher, or loupes with a magnification of 2.5 or higher [22]. In addition, these two procedures can be merged, enabling the evaluation of methylene blue dye staining under magnification.

Determining the necessary dentin support is another subjective decision. Previously, it was recommended to achieve a cusp thickness of at least 1.5–2 mm for enhanced restorative stability [23, 24]. If further reduction jeopardizes the restorability of the tooth, it should be halted when the preparation is sufficient.

After performing cusp reduction, it was concluded that preparing the dentin with air abrasion using 27-μ aluminum oxide particles was a superior and more efficient technique compared to employing a bur. When dentin is treated, its fatigue resistance decreases, making deeper dentin tissue more prone to fractures [13]. The surface resulting from air abrasion is devoid of residual cracks and is deemed advantageous for injured dentin due to its enhancement of bonding agent efficacy [25].

1.3 Material and Technique Selection for Restoration

Multiple protocols have been suggested in the academic literature for handling CTS, each with its own specific constraints and possibilities. Clinicians have the option to select the procedure that most aligns with their requirements, taking into consideration criteria such as caution, effectiveness, and efficiency [26, 27]. As was already said, some researchers support removing the affected cusp completely. This lets treatment plans be made that include occlusal modifications that remove some teeth or filling in the empty space [28]. There is agreement among experts on how to handle incomplete cracks, with the recommendation being to use splinting to stabilize the tooth [26]. Splinting might hinder the advancement of fractures by preventing unwanted motions while applying pressure to the occlusal surface.

1.4 Immediate Management of CTS

When a diagnosis of CTS is made, especially on the mandibular lingual cusps, the primary goal is to alleviate symptoms and decrease the force applied to the tooth by modifying the way the teeth make contact with each other

[29]. According to FDI's advice sheet [12], if the broken tooth is not treated properly, it will gradually worsen and could finally result in the loss of the tooth. Stainless steel bands and copper rings, also referred to as extra-coronal circumferential splints, have the ability to diagnose and treat carpal tunnel syndrome (CTS) quickly and effectively. These materials serve as splints and have the ability to mitigate the potential long-term consequences of misdiagnosis. If the discomfort continues after utilizing the band or ring, the diagnosis may be altered, resulting in the need for endodontic therapy and/or crown restoration [30, 31]. An interim crown that provides complete coverage can stabilize the fracture and disperse the pressure exerted on the biting surface, thus reducing the pressure on the teeth. Nevertheless, the creation of temporary crowns is commonly seen as a process that requires a significant amount of time and effort [29]. Direct composite splinting (DCS) is a technique utilized for the immediate treatment of carpal tunnel syndrome (CTS) by making use of the "Dahl" phenomenon, which was initially explained by Banerji and his colleagues. in 2010 [31–34]. The Dahl technique is particularly applicable to localized tooth wear in the front portion of the oral cavity and aims to create interdental space without the need for tooth structure removal. DCS, or Dental Crown System, is a procedure that involves the restoration of interocclusal tooth connections by means of axial movement. This process is essential for achieving permanent restoration. Banerji and his colleagues. have demonstrated promising results in the management of teeth with incomplete fractures through the use of properly placed DCS (Direct Composite Resin Splints). Based on their research, they achieved a success rate of 86.7% throughout a three-month period of follow-up [32]. Following the planning phase, a direct resin composite is applied to connect the fractured sections to the biting surface of the tooth, thereby stabilizing it. A flat splint is positioned in the supra-occlusal position of the appropriate tooth, with a thickness of approximately 1.0–1.5 mm above the occlusal surface [27]. This method can be implemented with or without premeditation. Some authors advocate for minimizing functional cusps, while others favor a non-invasive approach [31]. The subsequent appointment is usually arranged for a period of two weeks after the current one. The objective of this prompt intervention is to address tooth encroachment and restore occlusal connections. The level of discomfort deemed intolerable when managing CTS with restorative methods, taking into account any prior restorations, determines the treatment strategy. If the tooth that is fractured has been previously repaired, it is necessary to undertake the "Remove the Restoration Path" procedure. Alternatively, in the absence of restoration, it is necessary to minimize all cusps prior to direct restoration, which is then monitored. If the discomfort is not unbearable, it is recommended to carry out and closely observe DCS. If the pain remains unbearable for the next two weeks, the individual will proceed with the "restored" course of action. If the patient does not experience unbearable pain, the doctor should allow the re-establishment of occlusion by promoting tooth intrusion and gaining inter-occlusal space. Afterwards, the DCS (dental composite system) is taken out, and direct or indirect restorations can be carried out and supervised [23]. Resin-based composite materials are frequently suggested for carpal tunnel syndrome (CTS) and can be utilized through direct or indirect methods. If there is no unbearable pain and no previous restoration on the damaged tooth, it is recommended to do the "reduction of all cusps" operation, which will enable immediate restoration. If there is no unbearable pain within the two weeks following the implementation of DCS, it is advisable to proceed with direct restoration. Furthermore, when dealing with oblique or vertical cracks, it is recommended to opt for direct restoration. Adhesive restorations are preferred in such instances because they have the capacity to absorb stress and redirect occlusal loads through axial walls, which helps in supporting the survival of the tooth [23]. Cracked teeth can be protected with either direct or indirect dental restorations. Nevertheless, direct restorations have shown higher percentages of survival when subjected to loads above 1000 N

[35]. Both paste-type and flowable composites have been used for the treatment of carpal tunnel syndrome (CTS) in several studies. Flowable composites are injected into fractures, particularly in areas with less biting pressure [1-3]. Paste-type composites can be utilized to reinforce and provide support for painful cusps during chewing. Indirect restorations, such as dental inlays, onlays, and full crowns, offer materials with superior mechanical properties compared to direct resin-based solutions. These machines require less human expertise and provide exceptional corrosion resistance, superior fitting to the margins, and optimal endurance. It has been shown in studies that using indirect MOD resin-bonded composites, ceramic inlays, and adhesive cementation can make teeth that are as strong when broken as real teeth [4]. Ceramic onlays are favored due to their exceptional durability and ability to maintain the structure of the tooth, especially in cases of cracked teeth where a full crown restoration might improve biomechanical stability [35]. Feldspathic porcelain, glass-ceramic, glass-infused alumina, and zirconia are often employed as materials for indirect CTS therapy. These materials exhibit distinct elasticity modulus values and clinical performance features [3].Prevention: Prevention is essential in stopping the development and advancement of CTS caused by medical, environmental, or hereditary factors. It is crucial for individuals to maintain optimal dental hygiene by using effective cleaning methods, promoting good chewing habits, and following a well-balanced diet (which includes refraining from activities like as clenching, excessive grinding, abrasion, bruxism, and consuming hard foods or betel nut). Furthermore, enhancing the frequency of oral examinations can be useful in preventing CTS, especially in older individuals. Healthcare practitioners should implement efforts to minimize secondary harm or the development of additional fractures in the affected tooth and adjacent teeth while treating patients with caries or periapical diseases. Dental prostheses, such as hard acrylic and soft splints, can effectively reduce the symptoms of CTS by equally distributing forces across the chewing system and reducing the frequency, though not the intensity, of teeth grinding. Consistent use of these appliances is vital, as discontinuing their use may result in a resurgence of muscle activity to previous levels [36]. If symptoms of carpal tunnel syndrome (CTS) manifest, occlusal adjustments or bonded restorations can be employed to mitigate further deterioration of the damaged tooth reference[37].

In conclusion, The selection of the preparation technique and the decision to employ either a direct or indirect restorative strategy can significantly impact the prognosis for teeth affected by CTS. However, the treatment of CTS in a therapeutic setting is challenging due to its complex origins, ambiguous diagnosis, and subjective decision-making. For this reason, it is important to have a complete decision tree that includes the choice of materials, the preservation of dental structure, the improvement of preparation, and the thought process behind restoration in order to effectively guide clinical care.

References

[1]. Ellis S. G. S. Incomplete tooth fracture - proposal for a new definition. British Dental Journal . 2001;190(8):424–428. doi: 10.1038/sj.bdj.4800992. [PubMed] [CrossRef] [Google Scholar]

[2]. Endodontists AAo. Endodontics: colleagues for excellence-Cracking the cracked tooth code. 1997.

[3]. Cameron C. E. Cracked-tooth syndrome. The Journal of the American Dental Association . 1964;68(3):405–411. oi: 10.14219/jada.archive.1964.0108. [PubMed] [CrossRef] [Google Scholar]

[4]. Hasan S., Singh K., Salati N. Cracked tooth syndrome: overview of literature. International Journal of Applied and Basic Medical Research . 2015;5(3):164–168. doi: 10.4103/2229-516x.165376. [PMC free

article] [PubMed] [CrossRef] [Google Scholar]

[5]. Cameron CE. Cracked-tooth syndrome. J Am Dent Assoc. 1964;68:405–11.

[6]. Yap EXY, Chan PY, Yu VSH, Lui JN. Management of cracked teeth: perspectives of general dental practitioners and specialists. J Dent. 2021;113:103770.

[7]. Geurtsen W, Schwarze T, Günay H. Diagnosis, therapy, and prevention of the cracked tooth syndrome. Quintessence Int. 2003;34(6):409–17.

[8]. Kim SY, Kim BS, Kim H, Cho SY. Occlusal stress distribution and remaining crack propagation of a cracked tooth treated with different materials and designs: 3D finite element analysis. Dent Mater. 2021;37(4):731–40.

[9]. Liao WC, Tsai YL, Chen KL, Blicher B, Chang SH, Yeung SY, Jeng JH. Cracked teeth: Distribution and survival at 6 months, 1 year and 2 years after treatment. J Formos Med Assoc. 2022;121(1):247–57. This clinical study presents the short-term and mid-term clinical outcomes of the treatment of cracked teeth which are useful for the diagnosisand outcome-based treatment planning.

[10]. Udoye CI, Jafarzadeh H. Cracked tooth syndrome: characteristics and distribution among adults in a Nigerian teaching hospital. JEndod. 2009;35(3):334–6.

[11]. Kahler W. The cracked tooth conundrum: terminology, classification, diagnosis, and management. Am J Dent. 2008;21(5):275–82.

[12]. FDI World Dental Federation. Crack tooth syndrome: an advide sheet for dentists and dental teams. https:// www. Fdiwo rldde ntal. org/ sites/ defau lt/ files/ 2022- 07/ FDI% 20Cra cked% 20Too th% 20Syn drome. pdf. Accessed 23 Aug 2023.

[13]. Bailey O. Cracked tooth syndrome management part 2: integrating the old with the new. Dent Update. 2020;47(7):570– 82. This literature review presents follows on from Part 1 which looked on the diagnosis of cracked tooth syndrome (CTS). It provides scientific evidences of modern and predictable treatment concepts of CTS management with the aid of a decision-tree.

[14]. Alkhalifah S, Alkandari H, Sharma PN, Moule AJ. Treatment of cracked teeth. J Endod. 2017;43(9):1579–86.

[15]. Eltit F, Ebacher V, Wang R. Inelastic deformation and microcracking process in human dentin. J Struct Biol. 2013;183(2):141–8.

[16]. Forster A, Braunitzer G, Tóth M, Szabó BP, Fröter M. In vitro fracture resistance of adhesively restored molar teeth with different MOD cavity dimensions. J Prosthodont. 2019;28(1):325–31.

[17]. Tezvergil-Mutluay A, Pashley D, Mutluay MM. Longterm durability of dental adhesives. Curr Oral Health Rep. 2015;2(4):174–81.

[18]. Panahandeh N, Torabzadeh H, Ziaee N, Mahdian M, Tootiaee B, Ghasemi A. The effect of composite thickness on the stress distribution pattern of restored premolar teeth with cusp reduction. J Prosthodont. 2017;26(5):440–5.

[19]. Kois DE, Chaiyabutr Y, Kois JC. Comparison of load-fatigue performance of posterior ceramic onlay restorations under different preparation designs. Compend Contin Educ Dent. 2012;33(3):2.

[20]. Roma M, Hegde S, Mallya PL. Criteria for management of cracked tooth syndrome: a review. J Int Dent Med Res. 2020;13(3):1198–203.

[21]. SiddikNoorsaeed A, Abdullah AlMuhanna M, Hussain Aljurbua L, AbdulazizAlturki S, Omar Balubaid

N, Mohammed Alfaraj Z, WahbiAlbishi NK, MaithamAlnahwi A, AbdullahAlsalem A, MohammedaliAlsumur A, AbdullahAlsalem M, IbrahimBinHussain O, ShawqiAlgheryafi S. Diagnosis and management of fractured teeth; review article. J Pharma Res Int. 2021;33(56):129–34.

[22]. Zidane B. Recent advances in the diagnosis of enamel cracks: a narrative review. Diagnostics. 2022;12(8):2027–38.

[23]. Hamburger JT, Opdam NJM, Bronkhorst EM, Huysmans MCDNJM. Indirect restorations for severe tooth wear: fracture risk and layer thickness. J Dent 2014;42(4):413–418. This in vitro study compares the direct composite and indirect composite and ceramic restorations for severe tooth wear treatment in terms of the fracture risk. The results are important for the material selection in treatment planning of CTS cases, clinically.

[24]. Demarco FF, Corrêa MB, Cenci MS, Moraes RR, Opdam NJ. Longevity of posterior composite restorations: not only a matter of materials. Dent Mater. 2012;28(1):87–101.

[25]. Mujdeci A, Gokay O. The effect of airborne-particle abrasion on the shear bond strength of four restorative materials to enamel and dentin. J Prosthet Dent. 2004;92(3):245–9.

[26]. Li F, Diao Y, Wang J, Hou X, Qiao S, Kong J, Sun Y, Lee E-S, Jiang HB. Review of cracked tooth syndrome: etiology, diagnosis, management, and prevention. Pain Res Manag. 2021;2021:1–12.

[27]. Banerji S, Mehta SB, Millar BJ. The management of cracked tooth syndrome in dental practice. Br Dent J. 2017;222(9):659– 66. This literature review presents the short- and long-term clinical management reatment strategies for CTS.

[28]. Griffin J. Efficient, conservative treatment of symptomatic cracked teeth. Compend. 2006;27:93–102.

[29]. Cope A. Cracking up? Getting to grips with cracked tooth syndrome. Dent Nurs. 2012;8(5):290–3.

[30]. J Lee S Kim, E Kim, KH Kim, ST Kim, Y Jeong Choi. Survival and prognostic factors of managing cracked teeth with reversible pulpitis: a 1- to 4-year prospective cohort study. Int Endod J. 2021;54(10):1727–1737.

[31]. S Banerji, SB Mehta, BJ Millar. Cracked tooth syndrome. Part 2: restorative options for the management of cracked tooth syndrome. Br Dent J. 2010;208(11): 503–514.

[32]. Banerji S, Mehta SB, Kamran T, Kalakonda M, Millar BJ. A multi-centred clinical audit to describe the efficacy of direct supra-coronal splinting–a minimally invasive approach to the management of cracked tooth syndrome. J Dent. 2014;42(7):862–71.

[33]. Dahl BL, Krogstad O (1985). Long-term observations of an increased occlusal face height obtained by a combined orthodontic/ prosthetic approach. J Oral Rehabil. 1985;12(2)173–176.

[34]. Dahl B, Krungstad O, Karlsen K. An alternative treatment of cases with advanced localised attrition. J Oral Rehabil. 1975;2:209–14.

[35]. Naka O, Millar BJ, Sagris D, David C. Do composite resin restorations protect cracked teeth? An in-vitro study Br Dent J. 2018;225(3):223–8.

[36]. Agar J. R., Weller R. N. Occlusal adjustment for initial treatment and prevention of the cracked tooth syndrome. The Journal of Prosthetic Dentistry . 1988;60(2):145– 147.

[37]. Green J. I. Prevention and management of tooth wear: the role of dental technology. Primary Dental Journal . 2016;5(3):30–34.