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Vertical root fractures in teeth with endodontic treatment - literature review

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Abstract

Vertical root fractures (VRFs) are characterized by complete or incomplete fractures that extend through the long axis towards the apex. They may occur when the root fractures are fatigued by external forces. Endodontic treatment is efficient in the treatment of root canals, where the infection of the pulp is eliminated. The treatment can be used to avoid contamination of the infected area by microbes. However, complications are likely to be experienced if recontamination is experienced on the teeth. Therefore, the endodontist should have the necessary skills and qualifications in treating the condition. This literature review discusses vertical root fractures in teeth with endodontic treatment and the likely complications. This literature review found that the relationship between VRF in teeth that were endodontic treated may be affected by personal and social factors. The general health status of an individual may influence the response to endodontic treatment. Tooth factors, microbes, foreign bodies, and epithelial cells may affect the impact of endodontic procedures. These effects may influence the prevalence of VRF. The studies analyzed indicated that premolars and molars are at high risk of VRF as compared to incisors. Therefore, the diagnostic procedures may focus on the prevalence factors. However, personal responsibility, including hygiene, regular check-ups, and follow-ups, may eradicate post-endodontic complications.

Key words: *vertical root fractures, endodontic treatment, postendodontic complications.*

Introduction

Overview of the condition

VRF may lead to tooth extraction after post-endodontic treatment if the condition is not treated. Olcay et al. found that the first molar was prone to extraction due to VRF. This indicates that the condition affects the strength of the teeth, and complications may occur. The study by Olcay et al. further reported that the prevalence of VRFs is 7.02%, which is almost the same as previous studies. The prevalence rates indicate that the condition is among the community and needs to be addressed. The recording of the number of VRF cases may be determined by the diagnostic capabilities present [1].

Additionally, the prevalence rates may depend on a wide range of factors, including personal and social factors. The study by Olcay et al. found that 58.8% of VRF patients were females, and the meantime of the condition was 45 months. This indicates that the patients who had undergone endodontic treatment had a high likelihood of acquiring VRFs. Unfortunately, VRFs are severe complications with a poor prognosis. Hence, in case of a con-firmed diagnosis, therapy of VRF is the extraction [2].

Endodontic treatment

Dentists use endodontic procedures to manage inflammation and necrotic teeth that require root fillings. Lechner and Vv argued that procedures are safe and successful because previous patients have not complained. Therefore, the traditional therapeutic may be avoided and embrace the new technology. However, some patients may opt for root canal treatment, which may be difficult to treat inflammation. The study further argued that root canals might lead to immunological diseases, and X-ray imaging may be insufficient to provide definite analysis. This may alter the treatment procedures; thus, endodontic treatment is recommended [3].

VRF may develop after some days after the endodontic procedure. Endodontic treatment aims to preserve the natural teeth and maintain dentition's full function [4]. This is a critical aspect of a human being because dentition is beneficial to an individual. The procedures are effective because they help in maintaining the dentition tissues and avoiding further damage. Therefore, it is highly recommended to avoid infections [4].

Endodontic treatment may be surgical or non-surgical, depending on the extent of the damage that is desired to be repaired. The non-surgical endodontic treatment aims to provide a clean root canal that may be having bacteria [4]. Bacterial infections may lead to pathological effects that may affect the tooth structure. The treatment is also aimed at providing a coronal seal that prevents the pulp chamber from being re-contaminated [4]. Re-contamination can be dangerous to the tooth because of the adverse effects likely to be caused. Therefore, non-surgical treatment may help in avoiding contamination of the tooth.

On the other hand, endodontic treatment has been recorded to cause VRF on the teeth that have undergone the procedures. However, it is complicated to determine a VRF in teeth caused by the endodontic treatment or other conditions. Khasnis et al. (2014) suggested that reuniting fractured teeth has varying results based on the tooth's condition. Therefore, extraction is highly recommended to avoid further complications. VRF caused by endodontic procedures may be confused with periodontal disease or failed root canal treatment [5]. Therefore, proper diagnosis is required for an effective treatment approach. However, Khasnis et al. (2014) suggested that radiographic diagnosis, dental history, and clinical signs may be used in the diagnosis [5].

Vertical root fractures

Vertical root fractures (VRF) associated with endodontic treatment are one of the clinical problems hard to diagnose and treat. However, early detection may be effective in having a holistic treatment to avoid complications. Pia et al. (2019) defined VRF as a tooth fracture that runs along the long axis originating from the apex to the coronal part [6]. The condition may happen during or after endodontic treatment. VRF may be classified based on the separation of fragments and the fragments' position [6]. The fracture may be complete or incomplete based on the extent of the fracture. In some clinical cases it is very difficult to observe crack/fracture line without additional methods, e.g. transillumination or dyes (Fig.1).

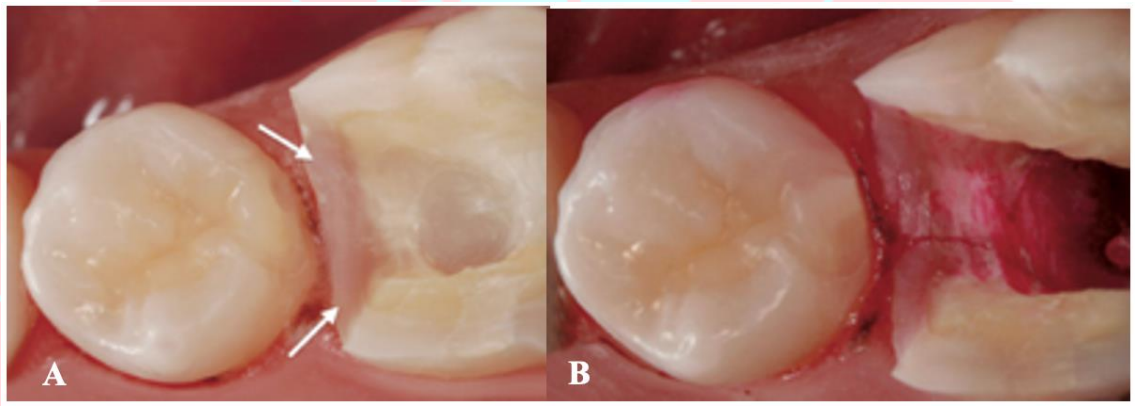

Fig.1 Vertical root fracture in mesial root on tooth #36: A/ Observation of the gingival wall; B/ The gingival wall after the caries indicator application (for ex-ample - fuchsin).

The study by Augusti and Augusti (2018) suggested that 18% of VRFs are developed after one year of endodontic treatment. This complication is based on the levels of compliance with the right protocols. Potential complications may be experienced on damaged teeth after multidisciplinary approaches and followed by a long time [7]. The occurrence of VRF depends on the level of endodontic procedures done to patients. Endodontic treatment may involve stainless steel manual files and rotary Ni-Ti instruments along with irrigations and the single-cone gutta-percha techniques [7].

Etiology

The recovery of compromised teeth may likely cause complications before full recovery. Endodontic treatments may affect structural integrity and retreatments, especially during canal shaping [7]. The procedure may cause stress on the tooth structure, which may later lead to VRF. The use of irrigants is associated with the deterioration of non-vital teeth' dentinal properties. The chemical agents may act on the tissues and cause adverse effects if unproperly used. Chemical and mechanical agents used in endodontic may lead to radicular dentin loss [7]. This may increase the risk of fractures to teeth during and after endodontic treatment.

According to Pia et al. (2019), the etiology of VRF comes either from endodontic treatment or restorative treatment. However, the fracture may occur because of habits that affect the tooth tissues, including chewing ice. In the case of endodontic treatment, the cavity preparation activities may destroy the mechanic structure, thus weakening the tooth structure [6]. The treatment may also cause tooth fracture because of

the activities of the treatment during the cleaning and shaping of the root canal. The local chronic inflammation may happen due to infection after the treatment. The soft tissue may be inflamed because of the microbes thus, causing inflammation [6].

Additionally, Hsiao et al. (2020) suggested that people aged 50 years and above had a higher risk of VRF. The clinical factors associated with VRF may help understand the appropriate approach to use in the treatment process. Diagnostic factors and clinical factors, including tooth type, abscesses, and age, are likely to be experienced for VRF in teeth [8]. Addressing the diagnostic factors may be effective in having an appropriate preventive plan. This may help in avoiding the complications related to endodontic treatment.

Diagnosis of VRF

Signs and symptoms may be used in the diagnosis of VRF based on the patients' clinical presentation. Remya et al. (2015) suggested that observational techniques and other conventional methods, including radiographs and illumination, may be used to diagnose VRF. Patients with VRF may also have moderate pain when chewing, bad taste, and swelling on the soft tissues [9]. In severe cases, some patients may experience bleeding when the tissues are stressed. The diagnosis will help in understanding the appropriate method to use to avoid complications. The history of the patient may also help in understanding the previous endodontic treatment used. This will help in forming a holistic treatment approach based on the approaches used previously.

The diagnosis of VRF may be complicated if the fracture line is not visible in the cervical region. Pia et al. (2019) suggested that VRF may be diagnosed using the aids of bite test, transillumination test, periodontal probing tests, and visual illustration. The tests involve radiographs and technological aspects that help in understanding the condition. Disclosing dyes, flowmetry, and strong coaxial illumination may help a clinician visualize the crack after magnifying [6]. The choice of diagnostic method will depend on the tools, resources, and skills available. However, the condition of the patient must be considered in the diagnosis stage.

Today, there is still no conclusive evidence to support diagnostic accuracy and efficacy for clinical and radiographic assessment of VRF [10]. The differential diagnosis of VRF from other pathological conditions can be difficult because there are no typical clinical or radiographic signs or symptoms associated with VRF [11,12]. Some of the retrospective studies discuss the most common signs and symptoms - deep probing defects (64-93%), sinus tract 22(13-42%), periodontal abscess and, mild to moderate pain (41-66%) [12,13,14]. There is a need for evidence-based research to clarify the currently unknown situation is crucial [10].

Effects of VRF in Teeth with Endodontic Treatment

The loss of tooth structure may affect an individual's self-esteem, especially for those who value teeth structure as beauty. Therefore, VRF may influence personal behaviors that are likely to affect an individual. The tooth abscess may affect personal characteristics, which are based on the treatment levels. VRFs may lead to tooth structure loss due to endodontic procedures that seek to re-move dental caries or trauma [8]. This may affect personal attributes because of the loss of tooth structure. It may be a threat to the self-esteem and confidence of an individual. However, the social perspective may also play a critical role in influencing personal characteristics.

Additionally, VRF may lead to increased health costs because of the complications. The complications may be due to infection of the tooth affected by the fracture. Therefore, an individual may be forced to seek medical support. Some of the medical procedures are expensive, and medical insurance services may not cater to them. This may lead to an increase in health costs, and individuals with low income may face such

challenges. The swelling or abscesses that occur in VRF in teeth require management. Therefore, resources may be required to enhance medical services. The patients will be required to use monetary resources to manage the condition and improve their quality of life effectively.

Vertical root fracture post endodontic complications

VRF can be considered to be a complication of endodontic treatment because the procedures may be destructive. This may depend on how healthcare professionals will manage the condition. If the endodontic procedure is done inefficiently, the tooth structure may be damaged; thus, affecting the condition of the patient. The study by Ossareh et al. (2018) suggested that endodontic teeth may resist fracture, which is a major concern. In addition, the cavities likely to occur may influence the mechanical integrity of the teeth. This may later affect the tooth structure and the health of the patient if complications of the teeth occur [15]. Additionally, post-endodontic complications are likely to occur because of failures during the treatment procedure. According to See et al. (2019), the complications may occur because of foreign body reaction, intraradicular/extraradicular infection, cyst development, and procedure errors. VRF may later arise but remain undetected until clinical symptoms are present on the patient. Some of the critical characteristics of VRF may include sinus tract, a J-shaped image of radiology, swelling/abscess, and periodontal pocket depth ≥ 5mm [13]. These factors may be critical in ensuring a positive impact on VRF patients. Two-canal mesial roots are much more prone to VRF than 1-canal distal roots. The researchers suggest that VRF may occur during clinical condensation of gutta-percha in the mesial roots of mandibular molars and other roots with canals connected by an isthmus (Fig.2).

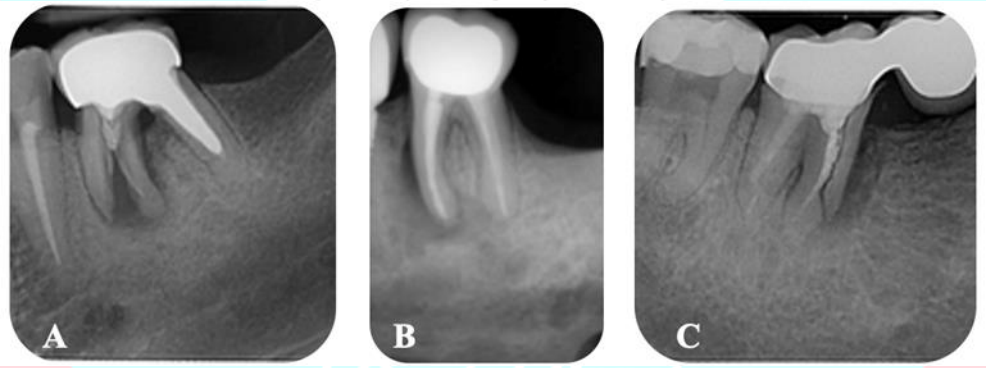

Fig.2 A-C The radiographic observation of mandibular molars (#36, #36, #47) with VRF shows that the line crosses the level of the alveolar bone in the apical direction in the mesial root in the apical direction in the radiographic observation.

The possible methods of treatment for teeth with VRF

Successful treatment of VRF may help in the improvement of the quality of life of the patients. Okaguchi et al. (2019) suggested that VRF teeth can be treated with intentional replantation and root fragment bonding with 4-methacryloxyethyl trimellitate anhydride/methyl methacrylate-tri-n-butyl borane (4-META/MMA-TBB) resin if the fracture line of the fragment reaches the level of the alveolar bone only. In other cases, when the line crosses the level of the alveolar bone in the apical direction, the clinical solution is the extraction [16](Fig.2).

The treatment can be successful if the procedure is done successfully - in a dry operative field. The 4-META/MMA-TBB resin has a high dentin bonding strength, high tensile, and favorable biocompatibility [16].

Follow-up is critical in ensuring that positive outcomes are achieved. It may help in ensuring the treatment procedure is effective towards the treatment of VRF. Okaguchi et al. (2019) suggested that treated VRF remained without clin-ical symptoms after 50 ± 15 months [16]. The teeth may also remain functional after the treatment. With the exception of other intentional re-plantation with adhesive resin cement [17-20] described by other authors, some other techniques such as utilizing CO2 laser to fuse VRFs are applied to improve the postoperative outcome [21]. But there is no specific treatment that has been provided ideal for long-term results. The treatment of VRF is critical for the bacteria present in the root canal that may damage the root surface [9]. Lack of treatment may lead to the inflammation of the root cavity, which can be painful. The treatment will be based on the diagnosis, and the images and information presented. Some of the clinical presentations may be dealt with therapeutic treatment for positive outcomes. Pia et al. (2019) suggested that calcium hydroxide may be used to promote tissue repair and resolve defects on the roots. The treatment can help in reinforcing the tooth structure and strength [6].

Additionally, multiple treatment modalities may be effective in dealing with VRF as a result of endodontic procedures. According to Pia et al. (2019), cyanoacrylate may be used in fragmenting the anterior teeth. The bonded segments are vital because they may help in resisting fracture of the root segment. The bond strength is vital because a patient may have a well-formed tooth structure. This may help in avoiding complications related to endodontic procedures [6].

Nevertheless, before treatment, the patients must be informed of the proposed procedure. Therefore, informed consent is vital before starting treatment and follow-up procedures. The root fragment bonding therapy may include benefits and risks, which should be informed to the patient [16]. This may help in re-specting the rights of the patient to be informed of the intended procedure. Ethical considerations are critical because they may help in improving patient outcomes. A holistic approach may be achieved by having a collaborative approach.

Factors affecting success of endodontic treatment

Unsuccessful endodontic treatment may lead to VRF in teeth after all the procedures. Therefore, understanding the factors affecting the success of endodontic treatment may be effective in avoiding complications. Khan et al. (2019) suggested that microorganisms may cause infections that may require endodontic treatment. The treatment helps in tooth restoration and relieves pain that is caused by infection [22]. Proper and accurate steps may be required to ensure positive outcomes are achieved after the treatment. This may help in overcoming some of the challenges that may hinder successful endodontic treatment.

Gender is one of the controversial aspects of healthcare that may affect the prevalence of diseases. The study by Hsiao et al. (2020) found a higher prevalence of VRFs in endodontic-treated females. The study also signified that the men who had VRF did not undergo endodontic treatment. Therefore, teeth that are subjected to endodontic treatment can be in the likelihood of VRF. Hsiao et al. (2020) also found that premolars and molars had a significantly higher risk VRFs than incisors. Thus, the tooth location is one of the critical aspects that influence the infections of the teeth [8].

The general health status may have an influence on the VRF in teeth with endodontic treatment. Khan et al. (2019) argued that older patients might take longer after endodontic treatment than younger individuals. The elderly populations are likely to face challenges because of the compromised immune system [22]. Therefore, the success of the endodontic treatment will depend on the body mechanisms and the immune system. According to Khan et al. (2019), bad oral hygiene may lead to complications after or during endodontic treatment. Therefore, patients are required to maintain proper hygiene for effective positive patient outcomes [22].

Additionally, the status of the tooth may have affected the success of endodontic treatment leading to VRF. Non-vital teeth with necrotic pulp may have challenges compared to vital teeth with pulpitis [22]. The presence of infection may prolong the treatment period, which may also cause discomfort to the patients. Khan et al. (2019) argued that endodontic operative steps might also lead to complications. The root canal should be cleaned and shaped accordingly. However, the lack of following the required steps may lead to root fractures because the cavity may be destroyed. When shaping the canals, it is essential to follow the curvature of the canal to avoid ledge formation [22]. Shaping the canal will be critical in avoiding VRF in teeth after endodontic treatment (Fig.3).

Microbes and foreign bodies may affect the success of endodontic treatment because they may cause complications. Khan et al. (2019) found that microorganisms may cause inflammation and endodontic failure [22]. The microbes may affect the dental tissues that may later affect the dental structure. Foreign bodies may affect the periradicular area in different ways like perforations, root fracture also overfilling of the root canal [22,23]. This may later lead to infections that may lead to inflammation. Therefore, a patient may feel uncomfortable because of the effects on the tooth structure.

Fig.3 Vertical root fracture on tooth #25.

Management and monitoring

The study by Remya et al. (2015) suggested that after a diagnosis of VRF, a quick decision must be made to extract the tooth or root. This immediate action may be critical because it may help in avoiding further infection. Re-plantation with VRF reconstructed with resin bonding may be an effective way to deal with the condition [9]. However, this management technique requires follow-up for effective management of the condition. According to Remya et al. (2015), prognosis re-plantation therapy depends on the systematic administration of tetracycline, disinfection, and atraumatic extraction of the fragments. The recovery of the procedure will also depend on the level of compliance with hygienic measures.

Additionally, the management of VRF with endodontic treatment will depend on the personal responsibility measures. The patients will be required to manage all the activities done to avoid further infection. This may include a healthy diet with minimal sugary foodstuffs in the diet. Personal responsibility will also involve following the treatment procedure to prevent complications. Therefore, follow-ups are critical towards the improvement of the complications that may arise after endodontic treatment. Collaborative approaches will also be required to ensure positive outcomes are achieved. The collaboration should involve health care professionals and patients to avoid the complications of endodontic treatment.

Regular check-ups are vital in the avoidance of complications related to endodontic treatment. Augusti and Augusti (2018) suggested that strict check-up attendance may effectively manage oral problems [7,24]. This may be done after endodontic treatment, where a patient may be advised for check-ups. This may help in avoiding complications after the endodontic procedures. During the check-ups, healthcare professionals may guide the best approach to deal with the tooth structure. The patients may also be advised on the best method to use to avoid complications. Compliance with the treatment schedule may help in preventing post-endodontic complications.

Conclusion

VRF in teeth with endodontic treatment may require special attention to address the condition. Endodontic treatment is done to avoid complications because of the infections and contamination of the tooth. However, the studies analyzed indicated that teeth that underwent endodontic treatment are likely to have VRF. The mechanical and chemical agents used during the treatment procedure affect the tooth tissues. The diagnosis of VRF is quite complicated because of the techniques, and after diagnosis, extraction of the tooth is recommended. The condition is highly prevalent in adults who were endodontic treated.

This literature review found that the relationship between VRF in teeth that were endodontic treated may be affected by personal and social factors. The general health status of an individual may influence the response to endodontic treatment. In addition, tooth factors, microbes, foreign bodies, and epithelial cells may affect the impact of endodontic procedures. These effects may influence the prevalence of VRF. The studies analyzed indicated that premolars and molars are at high risk of VRF as compared to incisors. Therefore, the diagnostic procedures may focus on the prevalence factors. However, personal responsibility, including hygiene, regular check-ups, and follow-ups, may eradicate post-endodontic complications.

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