REVIEW

Partial Pulpotomy Treatment In Young Permanent Teeth

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ABSTRACT

Partial Pulpotomy Treatment in Young Permanent Teeth

Teeth with healthy pulp or teeth with reversible pulpitis requiring pulpal treatment should be treated with vital pulp procedures. Vital pulp treatments include protective liner application, direct pulp capping, indirect pulp capping, and partial and total pulpotomy. Partial pulpotomy has a higher success rate as the infected pulp tissue is removed compared to direct pulp capping. Partial pulpotomy is more advantageous than total pulpotomy, as it preserves cell-rich coronal pulp tissues and increases physiological dentin deposition in the cervical region.

Partial pulpotomy treatment is applied to reach healthy pulp tissue by removing the inflamed pulp tissue 1-3 mm deep in teeth exposed with caries. Pulpal hemostasis and disinfection should be achieved using bactericidal agents such as saline, sodium hypochlorite, chlorhexidine gluconate, or laser. The pulp tissue should then be sealed with a biocompatible material such as MTA, calcium hydroxide, tricalcium silicate-containing material (Biodentine), calcium-enriched mixture (CEM) or Portland cement. MTA, which is frequently preferred as a pulp capping material in pulpotomy, should be placed at least 1.5 mm thick on the exposed area and the surrounding dentin, and resin modified glass ionomer cement should be applied on it. The tooth must be permanently restored.

The pulp tissue remaining after partial pulpotomy should be vital and symptoms and signs such as swelling, pain, and tenderness should not occur after treatment. Radiographically, internal or external root resorption, periapical radiolucency, abnormal calcification, or other pathological changes should not occur, and root development should continue in immature teeth and the apex should close.

KEYWORDS

Pulpotomy, Permanent Tooth, MTA, Calcium Hydroxide, NaOCl, Laser

ÖZ

Genç Daimi Dişlerde Parsiyel Pulpotomi Tedavisi

Pulpal tedavi gerektiren sağlıklı pulpalı dişlere veya reversibl pulpitisli dişlere vital pulpa prosedürleriyle tedavi uygulanması gerekmektedir. Vital pulpa tedavileri koruyucu liner uygulaması, direk pulpa kaplaması, indirek pulpa kaplaması, parsiyel ve total pulpotomiyi kapsamaktadır. Parsiyel pulpotomi, direkt pulpa kaplamasıyla karşılaştırıldığında enfekte pulpa dokusu kaldırıldığı için tedavinin başarı oranı daha yüksektir. Parsiyel pulpotomi, hücreden zengin koronal pulpa dokusunu koruduğu ve servikal bölgede fizyolojik dentin birikimini arttırdığı için de total pulpotomiden daha avantajlıdır

Parsiyel pulpotomi tedavisi, çürükle ekspoze olmuş dişlerde inflame pulpa dokusundan 1-3 mm derinliğinde kaldırılarak sağlıklı pulpa dokusuna ulaşmak için uygulanan bir tedavi yöntemidir. Pulpal hemostaz ve dezenfeksiyon serum fizyolojik, sodyum hipoklorit, klorheksidin glukonat gibi bakterisid ajanlar veya lazer kullanılarak sağlanmaktadır, daha sonra pulpa dokusu MTA, kalsiyum hidroksit, trikalsiyum silikat içerikli materyal (Biodentine), kalsiyumdan zenginleştirilmiş karışım (CEM) ve Portland simanı gibi biyouyumlu bir materyal ile kapatılmalıdır. Pulpotomide pulpa kapaklama materyali olarak sıklıkla tercih edilen MTA, ekpoze alana ve çevresindeki dentine en az 1.5 mm kalınlığında yerleştirilmeli ve üzerine rezin modifiye cam iyonomer siman uygulanmalıdır. Diş daimi olarak restore edilmelidir.

Parsiyel pulpotomi sonrasında kalan pulpa dokusu vital olmalıdır ve tedavi sonrasında şişlik, ağrı, hassasiyet gibi semptom ve bulgular gözlenmemelidir. Radyografik olarak internal veya eksternal kök rezorpsiyonu, periapikal radyolüsensi, anormal kalsifikasyon veya diğer patolojik değişiklikler gözlenmemelidir ayrıca immatür dişlerde kök gelişimi devam etmeli ve apeks kapanmalıdır.

ANAHTAR KELİMELER

Pulpotomi, Daimi diş, MTA, Kalsiyum Hidroksit, NaOCl, Lazer,

Pulp treatments are applied to maintain the vitality of the pulp of the teeth affected caused by caries, traumatic injury, or other reasons, and to preserve the integrity and health of the teeth and the supporting tissues.[1] The types, indications, and targets of the pulp treatments may vary depending on whether the pulp is vital or not, as well as on the clinical diagnosis, such as teeth with healthy pulp, reversible, symptomatic or asymptomatic irreversible pulpitis, or necrotic pulp.[2]

Vital pulp procedures should be applied to healthy teeth requiring pulpal treatment or to the teeth with reversible pulpitis.[3] Vital pulp treatments include protective liner application, direct pulp capping, indirect pulp capping, and partial and total pulpotomy.[1]

PARTIAL PULPOTOMY TREATMENT

Partial pulpotomy has a higher success rate compared to direct pulp coating because the infected pulp tissue is removed.[4] Partial pulpotomy is more advantageous than the total pulpotomy because it protects cell-rich coronal pulp tissues and increases physiological dentine accumulation in the cervical region.[5]

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Aguilar and Linsuwanont[6] evaluated studies on vital pulp treatments in vital permanent teeth with cariously exposed pulp. The success rate of partial pulpotomy treatments included in their study was 97.6% in 6 months to 1-year follow-up, 97.5% in 1- to 2-year follow-up, 97.6% in 2- to -3-year follow-up, and 99.4% in 3-year follow-up.

In studies with open apex teeth, success rates were higher with direct pulp capping (94.5%, 69.2%), partial pulpotomy treatment (94.6%, 90.6%), and total pulpotomy treatment (91.4%, 85.9%) compared to closed apex teeth.[6]

Histological studies have shown that the pulp of the cariously exposed teeth with vital pulp is not always fully infected.6 In some cases, inflammation has been shown to be localized only around the caries lesion and not spread to the entire coronal and radicular pulps, so it is possible to maintain the health of the remaining pulp if the infected pulpal tissue is removed.[6]

Partial Pulpotomy in Traumatic Exposures (Cvek Pulpotomy)

This is a treatment method applied by removing the infected pulp tissue to a depth of 1-3 mm in order to reach the healthy pulp tissue in permanent teeth exposed as a result of trauma.[1] Pulpal bleeding should be controlled using bactericidal agents, such as sodium hypochlorite or chlorhexidine,[7] then the pulp tissue should be capped with MTA[8], a biocompatible material.[9] White MTA is recommended instead of gray one to reduce discoloration in the anterior teeth.[1] MTA should be placed on the exposed area and the surrounding dentine with a thickness of at least 1.5 mm and resin modified glass ionomer cement should be applied on it.[10] The remaining pulp tissue after partial pulpotomy should be vital and no adverse signs or symptoms, such as swelling, pain, or tenderness, should be observed after treatment.[1] Radiographically, internal or external root resorption, periapical radiolucency, abnormal calcification, or other pathological changes should not be observed, and root development in immature teeth should continue and the apex should be closed.[1]

According to the literature, the treatment of the traumatized teeth in 9 days or earlier has been shown to have a minimal effect on the treatment results. While the exposed area of the pulp that is 4 mm or less affects the prognosis positively, the prognosis of a pulp with an exposing area greater than 4 mm is not clear.[11]

Although the difference in the results of pulpotomies in open or closed apex is not clear in the literature, a better prognosis has been observed in open apex, and a good restoration is necessary to prevent bacterial leakage in order to be successful in Cvek pulpotomy.[11]

In their study on monkey teeth with complicated crown fractures, Cvek et al.[12] reported that hemorrhage and odontoblastic layer damage did not pass 2 mm apical to the exposed pulp surface after 3 hours of trauma. Pulpal damage ranges between 1.5 and 2 mm after 48 hours of trauma and 0.8 and 2.2 mm after 168 hours (7 days).

Partial Pulpotomy in Permanent Teeth Exposed with Caries

Partial pulpotomy is a treatment method used to reach healthy pulp tissue by removing 1-3 mm depth from the inflamed pulp tissue in caries exposed teeth.[1] Pulpal bleeding should be controlled using bactericidal agents, such as sodium hypochlorite or chlorhexidine,[7] then the pulp tissue is closed with calcium hydroxide[8] or MTA.[13] Although high long-term success rates have been reported in treatment with calcium hydroxide, it was found that MTA produces more successful results in terms of dentine bridge formation and pulp protection.[14] Resin modified glass ionomer cement is applied after MTA is placed on the exposed area and around the dentine with a thickness of at least 1.5 mm.[15] The teeth should be restored with a material resistant to microleakage.[1]

Bleeding Control in Treatment with Partial Pulpotomy

Bleeding control plays an important role in the treatment of vital pulp.[16] In case bleeding control fails, the blood clot formed between the pulp tissue and the coating material will prevent the close contact of the coating material with the pulp and reduce the chronic inflammatory response required for healing.[17,18] There are some disadvantages of placing the pulp coating material on the blood clot or the bleeding pulp tissue. Blood clot has been shown to delay healing as it acts as a food source for bacteria reducing the effect of coating material on the pulp.[19] Bleeding under the coating material causes the material to dislodge, resulting in the formation of a fibrinopurulent membrane. This membrane is replaced by granulation tissue components. This tissue differentiates into odontoblasts and fibroblasts causing ectopic repair dentin formation.[17]

In partial pulpotomy or pulp coating treatments, the status of bleeding after pulp exposure is important because it provides information about the health of the pulp.[13] It was stated that the long clotting period was caused by irreversible infection of the pulp. Webber reported that pulp is irreversibly damaged in cases where the pulp bleeding lasts more than 5 minutes.[20]

Bogen and Chandler recommended direct pressure with cotton pellets impregnated with sterile water, saline, 2% chlorhexidine, MTAD (Tetracycline, Acid and Detergent Blend), 30% hydrogen peroxide (superoxol), ferric sulfate or NaOCl and laser to provide pulpal hemostasis.[21]

Hemostasis and Disinfection Materials in the Treatment of Partial Pulpotomy

1. Sodium Hypochlorite (NaOCl)

NaOCl concentrations of 1.5%-6% are used as the most effective and low-cost hemostatic agent for pulp coating and pulpotomy procedures.[21] Sodium hypochlorite is capable of dissolving organic tissues and causes irreversible enzymatic inhibition, disrupts cytoplasmic membrane integrity, and also acts by causing biosynthetic changes in cell metabolism and phospholipid degradation in lipid peroxidation.[18] Silva et al.[18] reported that sodium hypochlorite causes more reactive dentin production than chlorhexidine and saline. Sodium hypochlorite has the capacity to release mineralized dentin matrix[22] and growth factors, such as TGF-β.[18,23] TGF-β1 and TGF-β3 isoforms have been shown to be capable of stimulating extracellular matrix secretion in odontoblast cells, thereby stimulating the accumulation of reaction dentin.[23]

2. Physiological Saline Solution

Physiological saline solution is a 0.9% sodium chloride solution in physiological sterile water. Despite its limited contribution to the healing of pulp, it is the most commonly used agent for bleeding control in dentistry.[18]

In some studies, chlorhexidine and sodium hypochlorite caused a mild inflammatory response in pulp tissue, while no inflammatory response was observed after hemostasis with saline solution.[18]

3. Chlorhexidine Gluconate

Chlorhexidine gluconate precipitates cellular membrane proteins, changes cellular osmotic balance, and causes cell lysis.[18] Chlorhexidine, an antiseptic commonly used in dentistry, is an matrix metalloproteinase (MMP) inhibitor whose effect on the MMP 2, 8 and 9 in dentin has been proven.[24] Silva et al.[18] reported that sodium hypochlorite and chlorhexidine solutions did not prevent dentin formation and did not impair the structural healing capacity of the pulp tissue although they produced a mild inflammatory response on the pulp.

4. Tetracycline, Acid, and Detergent Mixture (MTAD)

MTAD is a mixture of 3% doxycycline, 4.25% citric acid and 0.5% polysorbate detergent.[25] MTAD weakens the dentinal walls by showing aggressive properties and even after the canals have been dried, there are residues of MTAD in the dentine tubules.[25] Therefore, the use of MTAD is avoided in children and pregnant women because of their detrimental effects on dental structures.[25]

5. Allium Sativum

The antibacterial effect of allium sativum has been shown to be due to allicin produced by the alliinase enzyme. Allium sativum has been shown to have an inhibitory effect on the growth of various pathogenic bacteria, viruses, and fungi. Although multidrug resistance was shown in Streptococcus mutant strains, garlic extract was found to have an inhibitory effect on these strains.[26] Previous studies have shown that allium sativum oil is a biocompatible material for vital pulp tissue. In addition, this material has been found to have a positive effect on the healing potential and the preservation of the function and health of the remaining pulp tissue.

Materials Used in the Treatment of Partial Pulpotomy

1. Calcium Hydroxide

This material, which acts by decomposing into calcium and hydroxide ions and exhibiting high alkalinity (pH 11), is used because of its antimicrobial properties[27] and induction of hard tissue formation.[28] Calcium hydroxide must be in contact with the pulpal tissue in order to form dentin bridge by forming mineralization.[29]

In the tissue adjacent to locality where the calcium hydroxide is placed, a necrotic region forms, and depending on the pH of this material, a dentin bridge occurs in response to the necrotic region, or the necrotic region resorbs and is replaced by dentin bridges.[30] Because calcium ions in calcium hydroxide do not combine with the resulting hard tissue,[31] although this barrier does not show integrity,[32] this material serves as initiators of reactions, not as substrates in repair.[33]

Calcium hydroxide material provides denaturing of bacterial proteins by breaking ionic bonds due to its high pH property, and shows antimicrobial effect by inhibiting bacteria growth.[29] The hydroxyl ions in this material cause the destruction of phospholipids, and by this way, break down the cell membrane of the bacterium, inhibiting replication by affecting bacterial DNA.[29] When calcium hydroxide was used for partial pulpotomy, the formation of dentin bridges in the coronal region was only achieved by the removal of the infected tissues, but no dystrophic calcification was observed in the canals.[34] When pulpotomy with calcium hydroxide is applied to caries exposed pulp, the recovery rate varies between 50% and 92%.[34]

2. Mineral Trioxide Aggregate (MTA)

MTA, a kind of type I Portland cement, contains water-soluble molecules, such as tricalcium oxide, silicate oxide, bismuth oxide, tricalcium silicate, tricalcium aluminate, and tetracalcium aluminoferrite.[35] Gray and white MTA consists of 75% Portland cement, 20% bismuth oxide, and 5% plaster.[35] White MTA was produced by removing aluminoferrite to eliminate the

produced by removing aluminoferrite to eliminate the coloration problem in gray MTA.[36]

Because MTA has good clogging properties,[37] it is biocompatible, and it forms dentin bridges in human[13] and animal teeth,[38] it is used in vital pulp treatment[29] as gold standard.

Although ProRoot MTA has traditionally been used in the treatment of vital pulp, it has some disadvantages, such as tooth discoloration,[39] presence of heavy metals (arsenic, chromium, and lead),[13] difficult use properties, long hardening time[13] and high-cost.

Some researchers have emphasized that MTA has low toxicity and high antimicrobial activity, induces cement formation, and increases periodontal ligament and bone development.[36] MTA causes the proliferation and differentiation of hard tissue cells by stimulating the release of interleukin-4 (IL), IL-6, and IL-8 cytokines.[39]

In animal studies, MTA has been shown to induce reparative dentin formation following mechanical pulp exposure.[38] These studies have reported that new matrix formation is observed by cellular inclusion over a 2-week period, and a tubular dentin-like barrier is formed in 3 weeks.[38]

3. Material with Tricalcium Silicate (Biodentine)

Biodentine (Septodont, Saint-Maur-des-Fossés, France) induces angiogenesis, cell differentiation, and mineralization in the pulp and also causes calcium and TGF-β secretion in the pulp cells.[40] The action mechanism of biodentine is described as it increases proliferation, migration, and adhesion of pulp stem cells when placed in direct contact with the pulp, and induces odontoblast differentiation. Compared to MTA, biodentine has some advantages, such as short curing time, better sealing, and low cost.[40]

4. Calcium enriched mixture (CEM)

The calcium-enriched mixture has similar properties to Biodentine.[41] The components of CEM are alkali earth metal oxides and hydroxides (calcium oxide, calcium hydroxide, calcium phosphate, and calcium silicate).[41] CEM cement and Biodentine are both biocompatible similar to MTA; however, they also have short curing time and good manipulation features, and cause no discoloration of the teeth. CEM has a cure time of 50 minutes whereas it is approximately 12 minutes for Biodentine.[41]

5. Enamel Matrix Protein

Platelet-rich fibrin (PRF) acts as a reservoir for slow and sustained release of growth factors. Smith and Lesort[42] reported that growth factors affect and guide the restorative dentinogenesis process. Huang et al.[43] concluded that PRF may increase the proliferation and differentiation of pulp cells. In angiogenesis and immune response, PRF plays a clot regulatory role.44 immune response, PRF plays a clot regulatory role.[44] Studies have shown that leukocytes and small lymphocytes in the PRF membrane are particularly effective in repairing inflammatory and infectious conditions.[44]

6. Portland cement (PC)

Portland cement is a hydraulic cement consisting of 65% calcium oxide (calcium+magnesium oxide), 20% silica, 10% aluminum and iron oxide, and 5% other compounds.[45] Unlike PC, bismuth oxide is added to MTA for radiopacity.[45] PC has been shown to cause dentin bridge formation in dogs after pulpotomy, and it has been shown to cause calcite crystal granulation accumulation in rats when placed in dentin tubules.[45] It can be used as a PC pulpotomy material and as an apical plug in apexification.[45]

The Use of Laser in Partial Pulpotomy Treatment

The success rates of laser pulpotomy treatments show comparable success rates with pulpotomy treatments with formocresol.[46] In direct pulp capping, the laser is used in pulps with inflammation because it stimulates the formation of secondary dentin, improves the pulp, and also reduces bacteria and by-products.[47] The use of Er,Cr:YSGG laser in pulp coating treatments contributes to the formation of dentin bridges, the creation of a sterile field, and the preservation of the vitality of the pulp. Due to the bactericidal effect of the laser, it creates a sterile field, which is a common effect on all wavelengths.[48] The coagulation effect of the laser results in a drier field of operation and produces a more superficial area of necrosis compared to chemical pulp coating materials.[48] Moritz et al.[49] reported that the laser beam minimizes the hematoma between the pulp tissue and the agent that closes the pulpal surface, and allows as close contact as possible between this material and the pulp tissue. The advantageous effects of laser on tissues can be listed as decontamination, hemostasis and coagulation effect, pressure reduction during cavity preparation, and biostimulation.[48,49] The biostimulation effect is a common feature of all lasers.[50]

It has been reported that the application of Er,Cr:YSGG laser on the exposed pulpal tissue yields successful treatment with direct pulp coating in permanent teeth.[48]

Olivi and Genovese[48] evaluated the combined use of erbium chromium laser and calcium hydroxide in direct pulp capping. Twenty-five decayed teeth were included in this study. In the first group, there were 13 teeth without pulp exposure, and in the second group, there were 12 teeth with pulp exposure. After cavity preparation, laser was applied to the 1st group for disinfection and to the 2nd group to obtain coagulation in the pulp. The cavities were then permanently restored by placing calcium hydroxide.

permanently restored by placing calcium hydroxide. As a result of this study, it was observed that the vitality of the pulp was preserved after 6 months in all cases treated with the Er,Cr:YSGG laser. It was concluded that the Er,Cr:YSGG laser is effective in pulp capping procedures.

Cengiz and Yilmaz[51] evaluated the efficacy of calcium hydroxide and resin-based tricalcium silicate (TheraCal) combined with erbium, chromium-doped yttrium, scandium, gallium, and garnet laser (Er,Cr:YSGG) in direct pulp capping in a randomized clinical trial. In this study, 60 teeth of the 60 patients between the ages of 18-41 years were included. The teeth were divided into 4 groups: calcium hydroxide group, laser-calcium hydroxide group, TheraCal group, and laser-TheraCal group. In all groups, the teeth were restored with nanohybrid composite resin in the same session by placing resin modified glass ionomer cement on the pulp capping material. The teeth were checked 1 week and 1, 3 and 6 months after treatment. As a result, the success rates in the calcium hydroxide and TheraCal groups were 73.3% and 66.6%, respectively. The success rate was found to be 100% in both laser groups. The combined use of TheraCal and calcium hydroxide with laser presented more successful results than the application of each of these materials independently.

Tozar ve Almaz[52] compared the efficacy of partial pulpotomy treatment using mineral trioxide aggregate (MTA) alone and MTA with the Er,Cr:YSGG laser in permanent immature molars in their study. Patients were recalled at 1, 3, 6 and 12 months after treatment. The success rate (95.5%) of the laser+MTA group was similar to that of the MTA group (88.8%). Partial pulpotomy treatment showed a high success rate in immature permanent molars; however, the use of the laser did not contribute to the success rate compared with MTA alone.

CONCLUSION

Apex formation in vital, young, permanent teeth can be achieved by applying vital pulp treatments, such as indirect pulp therapy, direct pulp capping, partial pulpotomy in traumatic, or carious exposed teeth. The pulp tissue remaining after partial pulpotomy should be vital, and symptoms and signs such as swelling, pain, and tenderness should not occur after treatment. Furthermore, radiographically, internal or external root resorption, periapical radiolucency, abnormal calcification or other pathological changes should also not occur. In addition, root development should continue and the apex should close in immature teeth. Partial pulpotomy treatment in permanent teeth provides successful results when appropriate indication is given. Further studies are warranted on this topic.

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