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MINIMALLY INVASIVE CARIES REMOVAL METHODS IN DENTISTRY

DİŞ HEKİMLİĞİNDE MİNİMAL GİRİŞİMSEL ÇÜRÜK TEMİZLEME YÖNTEMLERİ

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Abstract

The aim of a successful restorative treatment is to remove the dental caries and to regain the function by restoring the cavity with appropriate dental materials. While removing the caries, it is aimed to clean the demineralized soft infected tissue and protect the tissue that can be remineralized and the pulp-dentin complex. The current minimally invasive approach to cavity preparation and innovations in the production of adhesive materials have provided the development of new methods for caries removal. Especially in pediatric dentistry, painless interventions without the need for local anesthesia create comfort and confidence during treatment. The purpose of this review is to evaluate the literature on alternative caries removal methods.

Keywords: *dental caries; minimally invasive approaches; dentistry.*

Özet

Başarılı bir restoratif tedavi; diş çürüğünü uzaklaştırılarak kavitenin uygun materyallerle sızdırmaz bir şekilde restore edilerek fonksiyonunun yeniden sağlanmasıdır. Diş çürüğünün uzaklaştırılmasında; demineralize yumuşak enfekte dokunun temizlenerek remineralize olabilecek dokunun ve pulpa-dentin kompleksinin korunması amaçlanır. Güncel minimal girişimsel kavite hazırlama yaklaşımı ve adesiv materyallerin üretimindeki yenilikler çürüğün kaldırılmasında yeni yöntemlerin gelişmesini sağlamıştır. Özellikle çocuk diş hekimliğinde lokal anesteziye ihtiyaç duyulmadan yapılan ağrısız müdahaleler tedavi sırasında konfor ve güven oluşturmaktadır. Bu derlemenin amacı alternatif çürük kaldırma yöntemleri ile ilgili literatür değerlendirmesi yapmaktır.

Anahtar Kelimeler: *diş çürüğü; minimal girişimsel yaklaşımlar; diş hekimliği.*

OVERVIEW / GENEL BAKIŞ

In operative dentistry, dentin caries is divided into two layers as infected dentine and affected dentine. The infected dentin layer is the non-remineralized layer containing dense microorganisms. This layer contains remnants of necrotic tissue that can be stained with soft, caries fixation dyes due to irreversible denaturation of collagen, decalcification. However, the dentinal tubules are wide, the peritubular dentin is thin, and the collagen fibers are irregular. The affected dentin layer is a remineralizable layer with a regular collagen structure with moderate decalcification (1). Although this layer does not contain bacteria, it contains bacterial toxins and is not stained with caries detection dyes (2). It has been reported that infected dentin should be removed to prevent the progression of caries during caries removal, while affected dentin should be protected due to its remineralization ability and bacteria-free (3).

Black cavity principles in dentistry have been replaced by conservative minimally invasive approaches aimed at preserving healthy dental tissues with the developments in adhesive techniques (4,5,6).

Methods such as excavators, hand tools, burs, air abrasion, air polishing, use of ultrasonic tools, chemomechanical method, lasers, enzymes and atraumatic restorative treatment (ART) are used to remove caries (6).

Methods Used in Removal of Dentine Caries

The features expected from an ideal caries removal method can be listed as follows (6):

- It should be comfortable and practical to use in the clinic.
- It should only remove the caries, not harm the healthy tissues.
- It should be painless and quiet
- It should require minimal pressure, should not vibrate and generate heat during clinical practice.

High and Low Speed Instruments and Burs

Low and high-speed instruments are used as the most commonly used caries removal method in operative dentistry. Low-speed instruments are used for cleaning plaque and discoloration on the tooth surface, removing caries, finishing and polishing restorations (7).

Determining the amount of dentin that needs to be removed during caries removal with rotary instruments and burs is difficult because there is no objective evaluation criterion. Local anesthesia is needed to avoid from pain and discomfort in this method. In addition, factors such as cavity depth, pressure, and temperature can negatively affect pulp vitality (8,9).

Causes of pain during cavity preparation (6):

• Dentin sensitivity in teeth with vital pulp

• Pressure applied to the tooth, vibration

• It can be listed as the formation of high temperatures on the cutting surface

Air Abrasion

Air abrasion / kinetic cavity preparation method is based on the principle of using abrasive aluminum oxide particles with air pressure (4). Air-abrasion is used in restorative dentistry for purposes such as minimally invasive cavity preparation, fissure preparation, crown preparation, removal of tooth stains and calculus (10,11).

Today, it is thought that it can be used as an alternative to rotary instruments, especially in the treatment of initial lesions, since it is a painless method due to less heat and vibration during application (12). While this method is effective in removing soft dentin, it is less effective in removing healthy dentin. Thus, it ensures the removal of carious dentin and the preservation of healthy dental tissues (13,14). This method has disadvantages such as the lack of sense of touch in caries removing, the risk of particles causing respiratory diseases, and the need for clinical skills. In addition to cavity preparation, it can also roughen depending on the particle size (12).

Air Polishing

In this method, additional water pressure (corrosive sodium bicarbonate particles dissolved in water) is also used (15). It is used to remove deposits on the tooth surface, superficial enamel discoloration, plaque and dental calculus (16). It is suggested that this method can be used in the last stage of cavity preparation in caries removal (15). Although it is more advantageous in cleaning fissures on the tooth surface, it can spoil the polish of dentures and restorations (17). During air polishing application, the number of microorganisms in the environment and the risk of cross infection increase due to aerosols (15).

Ultrasonic Tools

In recent years, the technique known as sono-abrasion with high-frequency, sonic and modified abrasive tips with water cooling has been developed for the preparation of small cavities and minimally invasive cavity preparation procedures. It is recommended to be used after preparation as it is effective in removing caries by preserving healthy tooth tissue. In this method, the kinetic energy of water molecules is transferred to the tooth surface by the vibrations of the ultrasonic tip through abrasives (6). Although sono-abrasive tools do not affect the hard tissues of the teeth, they provide abrasion of the dentin thanks to their diamond-coated vibrating tips. With this method, a smear layer is formed during cavity preparation, as in traditional methods. It is known that sonic abrasive tips increase the surface area of the cavity, contribute to the acid etching and adhesion of enamel prisms, and cause less iatrogenic damage than preparations made with conventional instruments (18).

Atraumatic Restorative Therapy (ART)

The ART approach is a minimally invasive caries management that prevents or stops the progression of dental caries by improving oral health in areas with limited access to dental treatment. It includes the removal of caries using hand tools and restoration with a biocompatible high viscosity glass ionomer cement that releases fluoride that provides chemical adhesion to the tooth surface. Thus, pits and fissures prone to caries formation can be covered and cavitated caries lesions can be restored (19,20).

While expensive equipment is required in the traditional treatment method, simple hand tools are sufficient in the ART method. Since rotating instruments are not used in this method, only soft, demineralized dentin and unsupported enamel are removed, preserving healthy tooth tissue. In addition, since there is no pain during the procedure, it does not require anesthesia, and therefore it is preferred especially in the treatment of children, individuals with dental anxiety or mental retardation (21). However, this technique is not widely used in clinics yet, due to the problems that may arise with the caries remaining in the cavity. In order for this method to be widely used, studies evaluating caries control by microbiological methods and the effectiveness of different restorative materials with long-term clinical success are needed.

Regardless of the method used for caries removal, the most important factor for the success of the restorative treatment is whether there is a pathogenic microorganism that can cause residual caries and pulpal inflammation in the cavity. It has been shown that antigens of bacteria under restoration may cause the pulp and cause chronic pulpal inflammation (22). It is known that toxins of residual microorganisms can cause pulp irritation even in cavities that are very well isolated from the oral environment (23).

Silver Diamine Fluoride (SDF)

SDF application is one of the non-restorative caries treatment approaches. In this application, a 38% solution containing 253,900 ppm silver and 44,800 ppm fluoride ions with antimicrobial and remineralizing properties is used (24). Silver inhibits the growth of cariogenic biofilm, thanks to its antimicrobial properties. Fluoride, on the other hand, promotes remineralization and prevents demineralization of teeth during acid attacks (25). The reaction between SDF and hydroxyapatite helps to raise the pH and the formation of fluoride reservoirs, which facilitates the formation of fluorapatite thanks to silver phosphate and calcium fluoride (26). SDF also inhibits proteolytic peptidases in dentin and saliva. It also prevents the degradation of dentin collagen. In a systematic review, it has been reported that SDF is an effective agent to stop caries (27).

The use of SDF for the treatment of dental caries was introduced in Japan in the 1960s by Yamaga et al (28). In this approach to the control of dental caries, the silver and fluoride ions contained in SDF increase the resistance of the enamel against dental caries (29). SDF is preferred as a non-invasive approach in the treatment of dental caries, because it has advantages such as ease of use and low cost (30).

SDF application, as a simple, non-invasive, painless, inexpensive and non-aerosol-forming treatment, can be applied especially to pediatric patients and patients with special needs who are not suitable for traditional restorative treatment. But it has been reported that it causes burns on the mucosa or skin after application as a result of its high pH (31). The most frequently reported side effect of SDF is discoloration caused by silver phosphate (32). The discoloration of the anterior teeth, in particular, is a concern for children and parents. In order to alleviate this effect and increase patient acceptance, it has been recommended to apply potassium iodide solution after SDF application (33).

Chemical Caries Removal Method

In clinical practice, it is difficult to define the border between infected and healthy dentin. In chemical caries cleaning, caries is selectively removed by softening the denatured collagen structure chemically. Sodium hypochlorite can effectively dissolve soft tissues and denatured collagen in low concentration at high pH. However, the negative effect of sodium hypochlorite on healthy collagen limits its use in caries removal (4). Since only carious dentin is removed with this method, the risk of iatrogenic perforation of the pulp chamber in deep caries lesions is reduced. Other advantages of this method are that it does not require local anesthesia, and that no drill is used, reducing sound, vibration and pain (34). It is thought that not removing the unaffected dentin is effective in revealing fewer dentinal tubules and in reducing post-operative pain. Because it is less traumatic, especially pediatric patients are advantageous, but it requires a lot of time (35).

GK-101

GK-101, developed by Schutzbank et al., is a chemomechanical caries removal method produced by adding glycine, sodium chloride and sodium hydroxide to reduce the negative effects of sodium hypochlorite on healthy tissue. GK-101 provides removal of caries by chlorination of denatured collagen (36). Studies have shown that GK-101 solution is effective in removing caries and has no negative effects on healthy dentin and pulp (37).

GK-101E-Caridex

It is an agent that facilitates the removal of caries, which is obtained by replacing the glycine in the structure of Caridex GK-101 with amino butyric acid (38). The solution denatures the collagens of carious dentin and facilitates its removal (39). It has been shown that when caries is removed with Caridex, the smear layer is also removed, increasing the penetration of bonding agents and the retention of restorations (40). Since the method is painless, it does not require anesthesia and has advantages such as preservation of healthy tooth tissue. However, its clinical use is limited because it requires a long time and a large amount of solution in application (4).

Carisolv

It is a red gel containing 0.5% NaOCl and 3 amino acids (glutamic acid, leucine, lysine), NaCl, water, erythrosine, carboxymethylcellulose and NaOH. It disrupts the structure of denatured collagen and softens the carious dentin. Since the gel has a pH of 11, it does not cause any adverse effects on intact dentin (4). Since Carisolv does not penetrate healthy dentin, it does not damage the pulp tissue. As the pressure is eliminated with this method, infected dentin can be removed without pain, so it is especially preferred by children (35). Although Carisolv is effective in caries removal, it has not been widely used due to its disadvantages such as long working time and requiring the use of hand tools that increase the cost (41). It also requires the use of conventional rotary instruments to remove enamel to reach dentin (6).

Papacarie®

Papacarie® is a caries removal agent containing papain, a proteolytic enzyme. Since alpha-1-antitrypsin in healthy collagen inhibits the proteolytic effect of papain, only denatured collagen in carious dentin is affected in this method (41). The chloramine contained in this agent chlorinates the denatured collagen, allowing it to dissolve more easily (42). Papacarie has advantages such as successfully removing infected dentin tissue without affecting healthy tissues, not causing pain and discomfort during application, providing antibacterial effect, easy application and low cost (41,43). Papacarie is also known to affect the adhesion of restorative materials because it also removes the smear layer (41).

Carie-Care®

Carie-Care® is a chemomechanical caries removal agent containing papain enzyme. It also shows anti-inflammatory and mild anesthetic effects. Carie-Care® acts by softening the infected dentin (44). In a study, it was reported that Carie-Care® does not require local anesthesia, provides a reduction in dental anxiety, but requires more time during caries treatment than the traditional method (45) .

Biosolv®

Biosolv®, an enzymatic chemomechanical caries removal agent, contains the enzyme pepsin (46,47). This enzyme affects the denatured collagen in infected dentin and enables easy removal with hand tools (42). It has been reported that Biosolv leaves more caries-affected dentin than Carisolv and ART (36). However, it has been reported to be the most aggressive gel among chemomechanical caries removal gels due to its acidity (48).

BRIX-3000®

Papain-containing chemomechanical caries removal agent BRIX-3000® acts without creating proteolytic activity in undenatured collagen with its "α-1 antitrypsin" content (49,50). After BRIX-3000® gel is applied to the cavity, infected dentin tissue can be removed by changing the color of the gel (42).

Laser

The principle of the laser technique is based on the energy released from the laser source reaching the dental tissues and being absorbed by the water molecules. With this energy absorption, water molecules evaporate with the particles that they detach from the surface (51,52). Since the water and organic content of caries is higher than enamel and dentin, caries can be removed by laser. The disadvantages of CO2 and Nd-YAG lasers are that they can evaporate hard tissues with highintensity energy, cause carbonization and heat increase in the pulp. For this reason, Er-YAG lasers, which do not cause damage to healthy tissues during caries removal, are preferred in cavity preparations (53). Since laser caries removal does not create pressure and pain, it does not require anesthesia (54). However, the fact that the heat emitted from the laser can cause irritation in the pulp, the application control is difficult, technical knowledge is required and the cost is high limit its use (55).

Ultrasound technique

Ultrasound technique, which is one of the minimally invasive approaches, can be used for selective removal of the caries lesion (56). Vibration of ultrasound devices is provided by piezoelectric and magnetic methods (57). Vibration is produced by converting electrical energy into mechanical energy in the piezoelectric method. In the magnetic method, mechanical energy is generated by the change in the magnetic field through the transfer of magnetic electrical energy (58).

Ultrasound devices used in dentistry operate at a frequency of 25–40 kHz (59). In dentistry, ultrasound was used for the first time to prepare cavities by abrasion (60). Compared with conventional low- and high-speed instruments, the low-cutting efficiency of ultrasound devices is low, but caries removal is considered a more conservative approach as it is more selective (59,61).

Tunnel technique

The tunnel restoration technique is a minimally invasive technique for restoring the carious lesion on the interproximal tooth surface. Tunnel restoration was first proposed in the 1960s to restore proximal carious lesions in primary second molars (62). It can be considered as a more conservative alternative to traditional cavity design for interproximal caries in posterior primary teeth. Since the caries is removed by preparing a tunnel, the marginal protrusion is preserved (63). However, there are disadvantages such as insufficient caries removal risk and pulpal damage risk due to more limited access (64). However, this approach has reemerged with advances in restorative materials, a new generation of small-sized electric powered dental handpieces with light-emitting diode (LED) light, and the use of magnifying glasses to increase visibility (65,66).

SUMMARY / SONUÇ

It is important to eliminate bacteria that may remain in the cavity walls, enamel-dentin junction, smear layer and dentin tubules before the restoration is performed. These bacteria can maintain their activities in the cavity and cause postoperative sensitivity and pulpal inflammation. In order to prevent these complications, the use of antibacterial effective restorative materials, dentin bonding systems, etching preparations and cavity disinfectants have been considered for the inhibition of residual bacteria. However, research on this subject continues.

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