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Review article

TECHNIQUES FOR FIXED DENTAL RESTORATIONS REMOVAL - CLASSIFICATION, DECISION ON THE CORRECT APPROACH, ADVANTAGES AND DISADVANTAGES

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ABSTRACT

Introduction: Fixed dental restorations possess a predefined period of use. Most often they are removed by means of sectioning which renders them unusable. Reasons exist when practitioners shall preserve the restoration, applying conservative approaches for removing. In the literature, apart from the classic destructive technique with sectioning, conservative, semi-conservative and combined techniques for removal are described.

The aim of this article is to present a complete classification and description of different approaches to remove permanently and temporarily fixed prosthetic constructions.

Materials and methods: A literature study was conducted at the beginning of 2019. Information was gathered using dental textbooks on the topic specified and online scientific databases such as PubMed, ResearchGate, etc.

Conclusion Through this article, a conclusion was drawn that a full classification or description of removal techniques for fixed dentures has not been done in the Bulgarian literature so far. It is reported that information for patients about advantages, disadvantages and dangers of removing a permanently cemented restoration is of great importance. Except for the destructive ones, all methods described here may be used when removing temporarily fixated constructions. The selection of the ideal system or a combination depends on the clinical situation. Safest and most atraumatic for underlying structures when removing permanently cemented restorations is the destructive approach. Practitioners must be precisely familiar with the techniques so as to be able to preserve the construction, to avoid any danger connected with the clinical case. According to data gathered, no approach is universally applicable when removing fixed prosthetic restorations.

Keywords: correct removal techniquå, crown failure, dental crown remover,

INTRODUCTION

Fixed dental constructions possess a predefined period of use. Most often they are removed by means of sectioning after which they are unusable. Reasons exist when practitioners shall preserve the restoration, applying conservative approaches for removing. Apart from the classic technique with cutting, in the literature, conservative, semi-conservative and combined methods are described - useful to preserve the construction when removing it.

Discussing the time elapsed after cementing, we can distinguish two groups of clinical situations [1] (fig. 1):

1. Cases, when due to a mistake, removal must be implemented immediately after cementing.

2. Cases, when the cement has reached its maximal hardness qualities and strength potential.

In the second group of clinical situations, we can observe two main approaches:

2.1. Without preserving the construction.

2.2. With preserving the construction.

As it was previously discussed, fixed prosthetic restorations have a determined life duration [1-5]. According to literature data, the average life duration of crowns is 7-8 years [6, 7]. Although in some situations, crowns may be of use the whole patient's life, most often they are removed using the classic technique which renders them unusable [8].

Different extremely sparing, conservative and semi-conservative methods exist which aim at preserving the cemented restoration. Reasons for that may be for instance the necessity to treat root canals, secondary caries under construction to repair fractured porcelain, correction of mistakes made in shade selection, form and outline of the porcelain or acrylic veneering, etc. Other factors demanding intact removal of a fixed restoration are patient's age and health status, time spent on the case, esthetics, financial costs, social and psychological problems [6, 7].

Removal of a fixed dental prosthesis is an unpredictable procedure which may lead to various complications. All clinical cases demand an approach, maximally sparing tooth and periodontal tissues. Before removing the restoration, the dentist is unaware of the thickness of the material and the condition of the tissues underneath [2, 6, 7].

The aim of the following article is to present a complete classification and description of different approaches to remove a fixed prosthetic construction, based on a literature overview, and to discuss the advantages and the disadvantages.

MATERIALS AND METHODS

A literature study was conducted at the beginning of 2019. Information was gathered using dental textbooks on the topic specified and online scientific databases such as PubMed, ResearchGate, Google Scholar, etc. The following keywords were used: crown and bridge removal, crown and bridge disassembly, crown and bridge failure, techniques for removal, permanently cemented restoration, laser-assisted crown removal, etc. Latest data concerning the topic was published in September/October 2017.

RESULTS

Using the collected information, clinical reasons imposing removal of a prosthetic construction, are divided into four main groups [2].

✓ **Biological** - inflammatory processes in the pulp of the prepared teeth, abutment fracture, traumatic occlusion, pressure on soft tissues, poor oral hygiene, the necessity of retreatment, allergies to metal alloys, etc.

✓ **Mechanical** - inadequate restoration due to an absence of appropriate metal substructure, marginal distortion, etc.

✓ **Aesthetical** - improper shade selection of the veneering material and the cement, over contouring or protruding crowns or bridge, etc.

✓ **Cementing agent** - improper mixing technique, inadequate isolation, incomplete removal of the temporary cement, etc.

According to the time elapsed after cementing of the prosthetic construction, two groups of clinical situations are clearly distinguishable: cases demanding the immediate removal of the fixed construction after cementing (for instance due to a mistake), after remodeling papilla's contours, trying in the porcelain, after recontouring the pontic [1].

In the second group of cases, after the cementing agent has reached its maximal strength potential, we can distinguish two main approaches: with and without preservation of the restoration [1].

Sharma A, et al. described non-classified for the time being methods for removal of permanently cemented prosthetic constructions [3]. They divide the approaches into three groups, so as to facilitate the correct choice of approach and instruments needed according to the specific clinical case. The three main groups of techniques are as follows: destructive, conservative and semi-conservative techniques.

1. **Destructive techniques** - the dental restoration is completely destroyed since it is cut and removed.

2. **Conservative techniques** - the dental restoration is preserved and may be reused. Usually, this method demands grip and a hit.

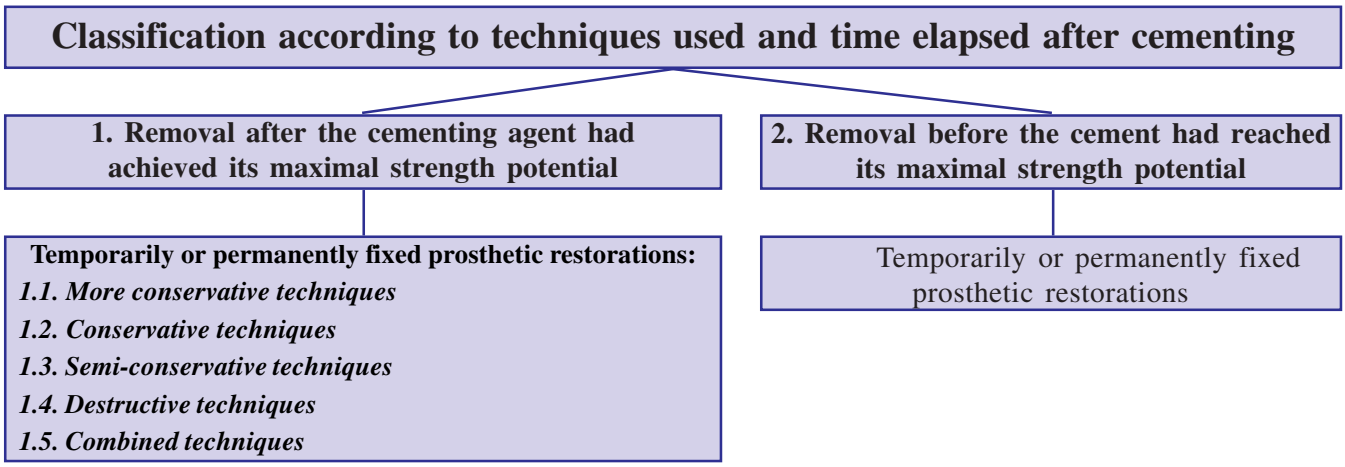
3. **Semi-conservative techniques** - these methods allow the dentist to re-cement the construction after adjustments [3, 5].

Salwa described the stated classification as well and discussed in details the conservative approaches [5]. It is imperative to have in advance the treatment plan before starting the removal procedure so as to protect the substructures. Factors such as general health status, quantity and quality of hard tooth tissues, possible prefabricated or cast post-retained restoration - materials used and design, possible lingual/palatal access must be taken into consideration [3, 4]. Other important factors include - cementing agent (newer generation materials are more difficult to remove), preparation design; periodontal status of the tooth; instruments and different removal approaches planned (maybe combined); the direction of the exerted force - should be parallel to the withdrawal direction(or the tooth axis) - a mistake here may heavily compromise the underlying tooth, core and any future restoration attempts [1, 2, 5 - 15].

Different systems and methods exist for crown and bridge removal. Little is known about the classification of the approaches which surely aids the correct decision according to the clinical situation. Al Moaleem MM suggested a modified combination of classifications from Addy et al., Sharma et al., Janardanan et al., Ingle et al., Rosenstiel et al., Alsiyabi and Felton and stated four groups of methods of removing failed prosthetic constructions [2, 3, 16 - 20]. 1. More conservative, 2. Conservative, 3. Semi-conservative, 4. Destructive.

According to the literature and after careful analysis, we can suggest the following classification adding an extra group of combined techniques:

Fig. 1. A classification of the different approaches to remove a dental prosthetic construction according to techniques implemented and the time elapsed after cementing.



Description of the different techniques:

1. More conservative techniques: we aim at breaking down the luting cement layer - this approach is the least dangerous for the restoration. It can be re-cemented again.

1.1. Ultrasonic

The technique for removing prosthetic restorations using special scalar tips **(Piezon Ultrasonic, EMS).** The approach might be applied alone or in conjunction with other techniques. It successfully destroys luting cement layers without damaging the restoration [3, 16, 17]. Melo Filho et al. stated that implementing ultrasound vibration at the gingival margin for 15 seconds causes a reduction in bond strength resulting in a breakdown of the cement layer [3, 16, 17, 21]. The technique may be combined with Richwill Remover. The apparatus is set to 5-10 vibrations/sec, and the scalar tip is pointed at the metal infrastructure of the restoration [22]. Ultrasound energy should be applied for sufficient time (5 or more minutes, if more teeth are engaged) along with the Richwill resin. Parreira et al. conclude that the approach is successful in 60% of the cases [22]. Combined techniques cannot be used on porcelain fused to metal restorations that are fully veneered with ceramics [16, 17, 22].

Disadvantages: time consuming approach, ceramic veneering may get fractured, heat generated can cause damage to the pulp (profound water spray is obligatory), proved the negative effect of ultrasound vibration on retention of restorations [3, 23]. Ultrasound techniques are contraindicated in patients with Hepatitis B and herpes simplex, as well as in patients with cardiac pacemakers [11, 16]. Manufacturers of ultrasound devices (Osada) warn that this approach is not successful with restorations cemented with zinc polycarboxylate and glass-ionomer cement [22].

1.2. Decementing with Richwill resin

Richwill is a water-soluble thermoplastic resin which, when compressed, generates strong temporary adhesive properties. According to Oliva, Richwill is suitable to remove temporarily and permanently fixed restorations [24]. The resin is softened in hot water for 2-3 minutes and then placed on the occlusal /incisal surface of the construction. The patient is then instructed to occlude and compress the resin block to 2/3 of its original size. The resin block is cooled with water. After around 10 seconds, the patient is instructed to suddenly open mouth rapidly and forcefully - the restoration gets fixed on the opposing teeth along with the resin [24]. This technique is described as the most effective approach towards dislodgement cast restorations. Oliva reports 100% success rate of this method towards removing temporarily cemented restorations and 60% successful for permanently cemented cast restorations combined with the ultrasound technique [24]. The success rate is bound as well to patient's cooperativeness.

Disadvantages: In some cases, the procedure needs repetition. The technique is contraindicated if the opposing tooth or the restoration are lacking stability [3, 7, 24]. To prevent accidental aspiration of the resin block, the manufacturer recommends tying dental floss to it [16].

1.3. Lasers

Lasers such as Er, Cr: YSGG 2780 nm may be used for the safe removal of all ceramic restorations. The procedure is fast, and there is no iatrogenic danger for the underlying structures. The wavelength of the laser is absorbed not by the porcelain structure - it passes through it, but by the water in the luting cement. Using Er, Cr: YSGG, 20 Hz for 1-2 minute for each side will contribute towards removing of the ceramic restoration. Application of lasers saves time and expenses, thermally softens the resin without any negative effect on the enamel. [25 - 37] Morford et al. made use of Er-YAG laser at the wavelength of 2940 nm, and 133 mJ output with the fiber tip positioned 3-6 mm from the surface of the restoration [26]. All ceramic veneers are debonded in 31-290 seconds.

Disadvantages: Limited application - mainly used for debonding all-ceramic restorations. Hazardous for hard and soft tissues if the tip is not positioned appropriately.

1.4. Crown tractors

The representative of this group is Trial Crown Tractors and Remover (Hu-Friedy Co, Chicago). Crown tractors work by firmly gripping the restoration with the aid of rubber and soft inserts at the beaks, designed to soften the connection between the restoration and the underlying tooth, without inflicting any damage on the porcelain margins. The pressure is applied to the two opposing handles.

Disadvantages: More applicable for single crown removal.

2. Conservative techniques

These systems work by applying a percussion or traction force to the luting agent, which results in a breakdown of the layer. The restoration remains intact and can be re-cemented. There is a chance to damage the core structures and periodontally involved teeth [2, 3, 17, 18].

Ewing J.E. described the application of a copper tape as an instrument to de-cement restorations in the past [38]. Copper tape and matrix band are put in firm contact with the tooth, after which they are filled with cement. After hardening, shaking force is applied - the crown is loosening up and removed. With new technologies being developed, this method is replaced with other approaches. Contemporary systems for crowns and bridges removal can be described as systems which create tensile forces in the luting agent resulting in cutting the layer. „Back-action" systems are offered in different types: manual, spring loaded, semi-automatic, spring loaded semi-automatic and pneumatic.

2.1. Removal with a chisel and a sliding hammer. This system comprises of a tip, selected to engage the crown margin. Afterwards, a weight is slid along the shaft in a series of quick taps. In' the market, various designs are available. Classic instruments are the manual ones operating with back-action-sliding hammers. They can be used to dislodge permanently fixated crowns and bridges, although their indications specify them in the field of temporary restorations removal.

Disadvantages: They are uncomfortable not only for the patients but for the practitioners as well and are no more used these days. It is not recommended to use them on periodontally compromised patients. Porcelain margins may be damaged [2, 16, 17].

2.2. Removal with back-action instruments

2.2.1. Back-action instruments with a weight. Those instruments engage the margins of the restoration with a tip, attached to a shaft, which has a sliding weight. Force is applied by manually activating the weight.

Disadvantages: A traumatic system for the patient. May cause discomfort and luxation of the periodontal ligament. It is mainly indicated for removing temporarily cemented restorations. Activation of the weight may cause the rod to shift away from the long axis of the tooth [1, 2, 16, 17, 39].

2.2.2. Spring loaded back-action remover. They are spring loaded, manually compressed and released to deliver the impact force [1, 3, 16, 17].

Disadvantages: The rod may easily shift away from the long axis of the tooth**.**

2.2.3. Spring loaded Semi-automatic remover. Operated easily with one hand, the other hand may be used to secure the tip of the remover at the crown margin. They have better directional control over the force delivered. Spring is compressed by sliding the outer cylinder over the inner one. Pressing the button provides back-action to remove the restoration. Devices of this type should be reactivated each time they are used [1, 2, 3, 16, 17].

Disadvantages: The tip may easily shift away from the margin and the long axis of the tooth/crown. More hazardous for the underlying substructures.

2.2.4. Pneumatic automatic back-action remover. This device is air-driven. A representative of this group is Antogyr Safe Relax. It is a modification of the sliding hammer using brass wire, looped through bridge embrasures, or a set of tips attached to the main device(compatible with all e-types of micromotors). After that, force up to 20 micro hits per second is applied [16, 17]. It is well tolerated by patients [1, 2, 16, 17, 19, 40, 41, 42].

Disadvantages: It is hard to determine the exact draw direction; the method is time-consuming and may cause discomfort to patients.

3. Semi-conservative techniques with partial destruction of the restoration.

These approaches include making a small access hole through the prosthesis. They are more convenient for patients, time-savers, force is inflicted less traumatically, restorations may be reused as provisional ones. The hole can be obturated using composite materials [1 - 3, 12, 16, 17, 43, 44]

Different instruments are developed for access through the hole made. The tooth is used as an anchor point, while the traction force is applied on the prosthesis. That breaks down the luting agent.

3.1. **The classic system - Mtalift Baton Rouge, LA**. Based on the concept of „jack-screw"- a precise hole is drilled with a diamond bur through the occlusal surface of the restoration. Then the area around the hole is undermined, and after that, a threaded screw is wound into space. The stated procedure generates a jacking force which destroys the cement layer and lifts the crown from the abutment tooth. Enough of the ceramic veneering should be removed around the hole so as to minimize the risk of cracks [2, 3, 7, 17].

Disadvantages: This system may not be used to remove cast post-retained substructures.

3.2. The Kline System (Brasseler USA) - stainless steel plier like instruments are used with one end having a pin 6 mm long and 1.6 mm in diameter, which engages a hole on the cusp tip, and the other end having a pointed tip, that engages the restoration margin. When squeezing the handle, the pressure is produced, which breaks the cement layer [3, 16, 17]. This system resembles Karnoff's technique with orthodontic pliers [12].

3.3. The Higa system - a wire is used, threaded under the soldered joint between pontic and crown - a parallel loop is formed, a support pin is inserted in the prepared hole on the occlusal surface. Tightening of the wire causes pressure to the restoration in an upward direction, which results in lifting, while the pin supports the underlying tooth [8, 16, 17].

3.4. The Wamkey system - a small tunnel is prepared on the buccal side of the crown between the occlusal surface and the interior surface of the restoration. After that in the tunnel, parallel to the occlusal surface, an oval key is inserted (available in 3 sizes) and is rotated around the axis 90 degrees. The crown is dislodged from the abutment tooth. The hole is filled with a restorative material [1, 3, 7]. Rotating the WAMkey breaks down the cement layer. The concept of WAMkey is not new - Tillman described a principle similar to it in 1965 [45]. On the buccal surface of the crown, a hole is made on the level between the occlusal surface of the crown and the occlusal surface of the prepared tooth. After that, in the hole, a long, round lever is inserted, and the crown is pushed in occlusal direction.

Disadvantages: difficulties in finding the exact spot to prepare the tunnel between the occlusal surface of the prepared tooth and the fitting surface of the crown.

3.5. Bucco-Lingual 'Dimple' Technique - dimples are created on the buccal and lingual surfaces of the fixed prosthesis with a small round bur in the gingival 1/3 (slipping of pliers from smooth porcelain or metal surfaces will be prevented) [17, 43]. Baade's pliers are used (Buffalo Dental, Syosset, NY), which are available in straight and angled variations.

Disadvantages: contraindicated when working on periodontally compromised teeth, unfavorable crown-to-root ratio and excessively mobile teeth.

3.6. Orthodontic removal - Karnoff reported a traditional orthodontic method to remove a restoration with pliers. A hole is drilled on the occlusal surface of the crown. Then one of the pliers' beak is placed in the prepared hole while the other beak is positioned at the margin of the crown. The pressure is applied, and the crown gets dislodged [12].

Disadvantages: This approach should be carefully implemented so as not to luxate the abutment tooth.

4. Destructive techniques with full destruction of the restoration

Applying this method, most common for all practitioners, restorations are usually sectioned with a diamond and/or tungsten-carbide bur. The technique can be combined

with an ultrasound instrument to disrupt the luting cement layer. Present-day adhesively bonded all-ceramic restorations may be extremely difficult to remove. A cut through the lingual surface might be necessary as well which renders the restoration totally unusable.

Additionally, inserting a crown spreader/lever or the special Mitchell's trimmers in the groove made on the surface of the restoration, using rotational moves split is spread evenly, and The rod may easily shift away from the long axis of the tooth cement layer breaks down. Other instruments are Christen-son Crown Remover trimmers.

The crown spreads evenly, reducing the tension on the tooth/core when using levers and trimmers. [1, 2, 5, 10]. Suitable for use are the widening plier's type. Squeezing the handle of the pliers allows the beaks to separate, which engages the prepared slot - the crown is deformed and split.

Although restorations made of the traditional dental ceramics may be cut through using harsh diamond burs, those diamond coating is of limited use on contemporary ceramic materials (highly resilient glass-ceramics and monolithic zirconia restorations). For contemporary reinforced ceramics: zirconium and other highly elastic ceramic materials are designed special drills - Komet ZR-Diamonds™, etc. They are characterized by a constantly adherent layer of high-quality diamond particles. Another method is to use Jackie 4ZRS - applicable both on frontal and distal restorations, made with a short (4mm), pointed working end.

5. Combined techniques.

The techniques include a combination of the abovementioned approaches. For instance, a technique using the special ultrasound scaler tips and the Richwill resin or removing a restoration applying the destructive technique in conjunction with an ultrasound instrument, etc.

The advantages and disadvantages of the various techniques and system are summarized as follows:

Table 1. Advantages and disadvantages of the various techniques and systems

System type & techniques	Advantages	Disadvantages
1. More conservative techniques		
1. 1. Ultrasonic	• Atraumatic removal of the crown • The least dangerous for the restoration	• Time consuming technic • It may require repair of restoration • The heat generated can cause damage to the pulp.
1. 2. Decementing with Richwill resin	• Reuse of the prosthesis • Less traumatic & easy to use	• Sometimes the procedure needs repetition. • The technique is contraindicated if the opposing tooth or the restoration are lacking stability • Not effective for permanent cementation.
1.3. Lasers	• Saves time & easy to use • Reuse of the prosthesis • Atraumatic technic	• Dangerous when laser beam not directed properly • Indicate only for all ceramic restoration
1.4. Crown tractors	• Safe removal of the crown	• Not effective for permanent cementation • More applicable for single crown removal
2. Conservative techniques		
2.1. Removal with a chisel and a sliding hammer.	• The restoration remains intact and can be re-cemented.	• Uncomfortable for the patients and the practitioners. • Contraindicated on periodontally compromised patients.
2.2. Removal with back-action instruments		
2.2.1.Back-action instruments with a weight.	• Simple design, not expensive	• Mainly indicated for temporarily cemented restorations.
2.2.2. Spring loaded back-action remover.	• Simple design, not expensive • Easier to deliver impact forces compared to manual back action	• The rod may easily shift away from the long axis of the tooth
2.2.3. Spring loaded Semi-automatic remover	• Can be used in a single handed manner. • Better directional control	• The tip may easily shift away from the margin and the long axis of the tooth/crown. • More hazardous for the underlying substructures.

2.2.4. Pneumatic automatic back-action remover.	• Automatic reactivation	• It is hard to determine the exact draw direction; • The method is time-consuming and may cause discomfort to patients.
3. Semi-conservative techniques with partial destruction of the restoration.		
3.1. The classic system - Mtalift Baton Rouge, LA.	• Less trauma to the tooth and surrounding structure, time saving	• This system may not be used to remove cast post-retained substructures
3.2. The Kline System (Brasseler USA)	• Less trauma to the tooth and surrounding structure, time saving • Applies a downward force on the tooth while the crown or restoration is removed, thereby preventing its fracture or extrusion	• Repairing the restorations. with esthetic restorative materials • Costly, need a lot of equipment's
3.3. The Higa system	• Less trauma to the tooth and surrounding structure, • Time saving	• Repairing the restorations. with esthetic restorative materials
3.4. The Wamkey system	• Less trauma to the tooth and surrounding structure, • Time saving	• Difficulties in finding the exact spot to prepare the tunnel between the occlusal surface of the prepared tooth and the fitting surface of the crown**.**
3.5. Bucco-Lingual 'Dimple' Technique	• Minimum intraoral grinding, • Impact force can be directed in a proper way with pliers by twisting motion of hand and wrist	• Not indicated in periodontally compromised teeth
3.6. Orthodontic removal	• Less trauma to tooth and surrounding structure	• This approach should be carefully implemented so as not to luxate the abutment tooth.
4. Destructive techniques with full destruction of the restoration	• The most atraumatic method to tooth and surrounding structure	• The dental restoration is completely destroyed
5. Combined techniques.	• Saves time & easy to use • Reuse of the prosthesis • Atraumatic technic	• Limited application

DISCUSSION

The more conservative techniques for removing cemented prosthetic construction have a 100% success rate, unfortunately only for temporarily fixated prostheses. Parreira et al. report that they are successful in 60% of the cases with permanently cemented restorations [22]. If ultrasound devices are used for prolonged periods of time, they can induce the formation of cracks in the ceramic material and pulp damage. On the other hand, lasers are being implemented to remove ceramic restorations [16, 26, 44]. The more conservative approaches are not reported to be successful with restorations cemented with zinc polycarboxylate and glass-ionomer cement [22].

Systems using a percussion or traction force provide an opportunity to preserve the prosthetic restoration. The main disadvantages of those techniques are the greater possibility to damage the substructure and the periodontal tissues [2, 3, 17, 18]. Often tips may accidentally shift away from the margin and the long axis of the tooth/crown. The procedure may be time-consuming when the exact direction of the force needs to be carefully defined [2, 8].

Semi-conservative approaches demand expensive restorative materials. They are contraindicated for periodontally compromised patients, unfavorable crown-to-root ratio and excessively mobile teeth.

Destructive methods allow practitioners to remove the restoration without any risk of damaging the hard tooth tissues and the periodontium. Unfortunately, they are time-consuming and unpleasant for patients.

CONCLUSION

Through this article, a conclusion was drawn that a full classification or description of the removal techniques for fixed dentures has not been done in the Bulgarian literature so far. No approach is universally applicable. All methods described here, except for the destructive ones, may be used when removing temporarily fixated constructions. Selection of the ideal system or a combination depends on the clinical situation.

Safest and most atraumatic for underlying structures when removing permanently cemented restorations is the destructive approach. Practitioners must be precisely famil-

iar with the techniques so as to be able to preserve the construction, to avoid any danger connected with the clinical case. It is reported that information for patients about advantages, disadvantages and dangers of removing a permanently cemented restoration is of great importance.

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