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TREATMENT

Esthetic and functional rehabilitation of worn teeth

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Abstract

Pathological tooth wear is a multifactorial and cumulative process that involves the destruction of dental hard tissues and compromises the patient's oral health. After an accurate assessment of the amount of worn dental tissues, possible loss of the vertical dimension, aesthetic and phonetic problems, minimally invasive restorations can be used in the rehabilitation of worn teeth after cost-benefit analysis. In addition, the patient should be informedabout the problem, the etiological factors and the clinical performance of the restorations needs to be monitored periodically.

Keywords Abrasion · Attrition · Erosion · Abfraction · Dental wear · Minimally invasive restorations

Quick reference/description

Pathological tooth wear is a progressive and irreversible process that includes the loss of dental hard tissues resulting in compromised oral health. Progressive tooth wear can cause esthetic, functional, phonetic and postural complications, which adversely affect a patient's quality of life. An appropriate diagnosis of tooth wear along with informing the patient about the relevant etiologic factors are essential for proper planning and implementation of treatment. Direct and indirect restorations

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can be used for treating worn teeth after a comprehensive review of several different factors.

Overview

Treatment modalities	Indications
Direct restorations	
Direct resin composite restorations	– Short- to medium-term solution for minimal to moderate amount of tooth loss – Management of abrasion and abfraction that are usually located in the cervical area of a tooth – Modification of tooth volume – Management of tooth wear in young patients
Indirect restorations	
Traditional full coverage prosthetic restorations	– Severe cases of pathological tooth wear – Clinical cases with loss of vertical dimension of occlusion - Management of worn dentition with the presence of carious lesions or aged prostheses
Minimally invasive indirect restorations	– Management of pathological tooth wear while maintaining maximum amount of viable dental tissue – Clinical cases with loss of vertical dimension of occlusion – Management of tooth wear in young and adult patients

Materials/instruments

- Resin composite material
- Bis-acryl composite resin
- Gypsum
- Computer-aided design and computer-aided manufacturing (CAD/CAM) system
- Articulator
- Rubber dam
- Diamond bur
- Hydrofluoric acid (HF) gel
- Feldspathic ceramics
- Lithium disilicate-based ceramics
- Leucite-reinforced ceramics

- Silane coupling agent
- Adhesive resin bonding
- Resin-based luting cement
- Universal bonding agent
- Micro-brush
- Nanocomposite resins
- Rubber tips and brushes
- Finishing disks

Procedure

Physiologic tooth wear is a natural process of ageing that is characterized by the loss of dental hard tissues during normal oral function. Dental tooth wear is considered pathological when abnormal and intense forces cause severe and irreversible loss of dental tissue.

Anatomy and morphology of the teeth are altered after dental wear. In addition, aesthetic problems, endodontics and risk of sensitivity may be present. Radiographically, it can be associated with secondary dentin deposition, sclerosis in the pulp chambers and root canals or hypercementosis.

Establishing an accurate diagnosis of tooth wear is crucial for dentists to devise an effective treatment plan. Tooth wear has a multifactorial etiology that results in different types of tooth wear like abrasion, attrition, erosion and abfraction. The main etiologic factors of pathological tooth wear are:

- Parafunctional habits
- Stress
- Inadequate diet (such as excessive consumption of citrus fruits, acidic juices, among others)
- Oral hygiene practices using excessive force
- Use of abrasive dentifrices
- Systemic disorders (as gastroesophageal reflux)
- Eating disorders (as bulimia)
- Unstable occlusal pattern

Fig. 1 Dental attrition in maxillary central incisors

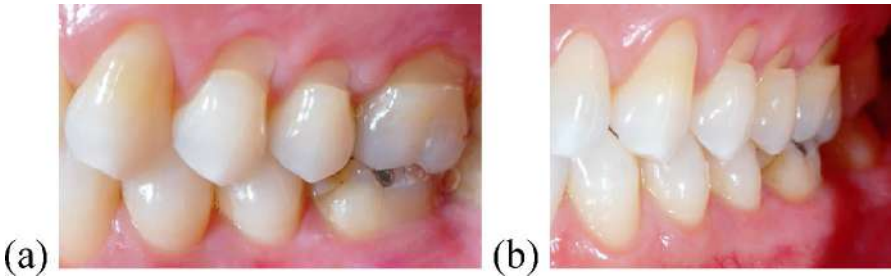

Fig. 2 Dental abrasion resulting from intense horizontal dental brushing

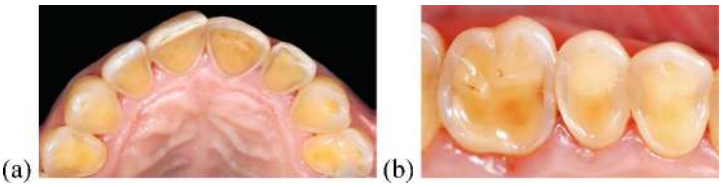

Fig. 3 Dental erosion on the palatal and occlusal surfaces

Types of tooth wear

Attrition

Loss of dental hard tissues due to intense contact between opposing teeth during mastication and other occlusal function is called dental attrition. A physiologic tooth wear amounts for 30–50 μm of enamel loss per year. Intense and abnormal loading accelerate of dental tissue destruction, causing tooth wear at a higher rate than the physiologic compensatory mechanisms. Attrition results in flat and shiny lesions with distinct borders and is usually accompanied by color change and dentinal exposure (Fig. 1). The most affected sites are incisal edges and occlusal and palatal surfaces.

Abrasion

Loss of dental hard tissues due to repetitive mechanical action of an external agent is called abrasion. The predisposing factors for abrasion are vigorous toothbrushing in a horizontal direction, using abrasive dentifrices, parafunctional habits like nail biting, use of tobacco pipes and insertion of objects in the mouth, and ill-fitting clasps of removable partial dentures. The contour of abrasion lesions is irregular. Lesions can also be wedge-shaped. They show smooth and shiny enamel with highly polished dentin. Abrasion can occur on the incisal edges or in the cervical regions of prominent teeth like maxillary canines and premolars depending on the etiology (Fig. 2). Cervical lesions are often accompanied by dentinal sensitivity.

Erosion

Erosion (corrosion) is a chemical process resulting in loss of tooth structure due to dissolution of dental hard tissues on exposure to acids or chelating agents. Erosive facets are common on the buccal, occlusal and palatal or lingual surfaces (Fig. 3). The lesions are rounded and irregularly-shaped due its gradual progression. Occlusal surfaces exhibit small depressions. Erosion is considered as the most complex type of dental wear owing to its multiple etiologies like:

- Intrinsic etiological factors: regurgitation involuntary (vomiting, gastroesophageal reflux, hiatal hernia and pregnancy) and voluntary (bulimia);
- Extrinsic etiological factors: excessive consumption of citrus fruits, acidic juices, soft drinks, alcohol, medications based on acetylsalicylic acid and ascorbic acid and illicit drugs;
- Environmental factors related to profession: chemical, pharmaceutical and wine industries;
- Idiopathic factors.

Abfraction

Pathological tooth wear occurring because of biomechanical forces is called abfraction. These forces cause dental flexion that leads to fatigue of mineralized dental tissues at a site that is distant from the site of occlusal loading. Abfraction is commonly seen on premolars with cervical lesions on the buccal surface (Fig. 4). The lesions are usually wedge-shaped with distinct external and internal angles and are located at the cementoenamel junction. An adequate occlusal analysis must be performed before the restoration of the abfraction lesion.

The different types of tooth wear can occur independently or in combination requiring an efficient follow-up protocol. The size and location of wear lesions dictate their diagnosis and management. Cervical lesions, such as abrasion and abfraction lesions, are usually located on the buccal aspect in small and medium size. The highest amount of dental tissues destruction occurs when dental abrasion is associated with erosion and attrition. In such cases, tooth wear usually starts on the lingual or palatal surfaces and extends to the occlusal or incisal and buccal surfaces. Dental wear can also be accompanied with loss of vertical occlusal dimension.

Fig. 4 Dental abfraction

Table 1 Classical Tooth Wear Index (TWI) proposed by Smith and Knight (1984)

Score	Surface	Criteria
0	B/L/O/I/C C	No loss of enamel surface characteristics. No loss of contour.
1	B/L/O/I/C C	Loss of enamel surface characteristics. Minimal loss of contour.
2	B/L/O/I/C C	Loss of enamel exposing dentine for less than one third of surface. Loss of enamel just exposing dentine. Defect less than 1 mm deep.
3	B/L/O/I/C C	Loss of enamel exposing dentine for more than one third of surface. Loss of enamel and substantial loss of dentine. Defect less than 1-2 mm deep.
4	B/L/O/I/C C	Complete enamel loss - pulp exposure - secondary dentin exposure. Pulp exposure or exposure of secondary dentine. Defect more than 2 mm deep - pulp exposure - secondary dentine exposure.

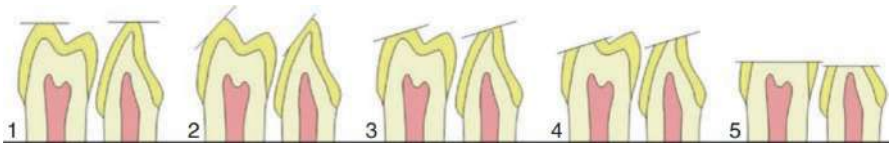

Fig. 5 Tooth wear severity. (1) Minimal wear, enamel only (2) Facets parallel to normal plane of contour, enamel only (3) Noticeable flattening of cusp/incisal edges, enamel only (4) Total loss of contour and dentin exposure (5) Total loss of contour, dentin exposure over half of former crown of tooth. Adapted from Pullinger and Seligman and John et al.

Loss of vertical dimension is the most prevalent and complex issue following tooth wear. Increased phonetic space and overload of periodontal tissues and temporomandibular joint are common in patients with loss of vertical dimension. In severe cases of vertical dimension loss, the face appears short because of reduced height in the lower third, increased lip contact and angular cheilitis.

Tooth wear can be measured via several qualitative and quantitative indices that can classify the severity of wear. 'Tooth Wear Index' (TWI) is the most commonly practiced index that assesses dental tissue loss on a scale of 0–4 (Table 1). Simplified and visual analysis methods can be used along with TWI (Fig. 5).

Treatment modalities for worn teeth

Due to the multifactorial etiology of tooth wear, a thorough preoperative patient evaluation involving total oral examination, medical history, intraoral radiographs and extraoral photographs (if required) is crucial. Direct or indirect restorations or a combination of both can be performed for oral rehabilitation of worn

dentition after identifying the etiologic factors. The final selection of restoration type should be done only after informing the patient about the following:

- Direct and indirect options
- Best combination of cost–benefit analysis
- Longevity of restorations
- Health of the remaining dentition

Generally, patients with worn dentition seek treatment for esthetic problems and are completely unaware of the severity of their oral condition. The patient must be clarified by the professional, and the dental wear lesions must be restored when the structural integrity of the tooth is compromised, masticatory efficiency is reduced, and dentin sensitivity, risk of pulp exposure or dental caries and aesthetic problems are present.

Cervical lesions due to abrasion can be restored directly after controlling for the main etiological factors. In patients with abrasion, professional advice about lesion etiology and proper brushing technique along with enhancing the importance of controlling parafunctional habits is essential.

In erosion and attrition cases, the control of the etiologic factors is more difficult due to the complex and multifactorial etiology. Before restorative intervention, the clinician should identify the causes of tooth wear, control and closely monitor the intake of acidic agents and refer the patient to specialized clinicians in case of existing systemic conditions. In these cases, the lesions may recur, compromising oral rehabilitation. Therefore, a multidisciplinary treatment that improves the patient's quality of life is vital for the success of complex cases with a risk of recurrence.

Selection of the restorative intervention usually depends on the site and amount of lost dental tissues. Direct restorations cannot usually restore severe tooth wear occurring due to erosion and attrition as tooth wear is commonly associated with functional problems. When the dental wear pattern involves the anterior teeth, esthetic issues are prevalent. Hence, the restorative intervention should be comprehensive with an aim to restore a patient's overall quality of life.

Direct restorations

Direct restorations are mainly performed in young patients or in cases of small amount of tooth wear as short- to medium-term resolutions. The restorations can be prepared with or without guides directly in the oral cavity. Thorough knowledge about dental anatomy and tooth proportions is essential while using the freehand method without guides for direct restorations. If multiple teeth require restorations, transparent guides obtained from waxing of a diagnostic model can be used to decrease chairside time and the need for acquired skills (index technique). It is indicated in cases of minimal to moderate tooth wear and for modification of dental volume. Direct restorations should be considered while restoring teeth in case of limited interocclusal space. The main advantages of direct restorations are:

- Conservative technique
- Reversible with low biological costs
- More economical with low financial costs

Direct resin composite restorations Resin composite is the most commonly used material for direct restorations. Its success largely depends on the clinician's manual skills and knowledge of adhesive dentistry. It can be used easily to restore small to medium lesions resulting from abrasion and abfraction. Excellent polishing of direct resin composites is crucial for longevity of the restorations. Resin composites require simple maintenance protocols via re-polishing or direct repair.

Indirect restorations

Indirect restorations are considered as the ideal choice for treating severe dental wear. Laboratory resin composites, ceramics, or hybrid materials are the most commonly used materials to manufacture indirect restorations. It is important to employ a minimally invasive restorative approach, whenever possible which also requires mastering adhesive procedures.

Traditional full-coverage prosthetic restorations Traditional full-coverage restorations should be considered only in cases of worn teeth with carious lesions or aged prostheses. Classical preparations are usually more aggressive as they need removal of sound dental tissues to construct prostheses of greater thicknesses to offer better resistance to masticatory forces. Hence, it can lead to sacrifice of more healthy tissue and possible loss of tooth vitality in comparison with additive or minimally invasive techniques.

Minimally invasive indirect restorations Direct and indirect restorations can be performed in a case of worn dentition based on the amount of remaining dental tissues. During minimally invasive tooth preparations, more viable dental tissue is maintained for durable adhesion. This technique needs a strong balance between the space gained following tooth preparation and the required minimum thickness of the selected restorative material. Therefore, the interdental space that presents after the

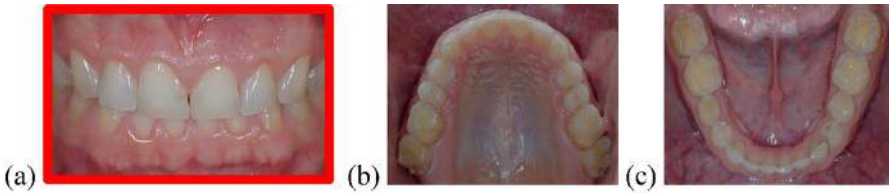

Fig. 6 **a–c** Moderate tooth wear on anterior teeth and minimal wear on posterior teeth in a young patient

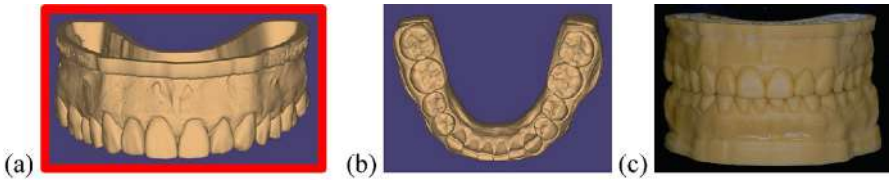

Fig. 7 **a–c** Digital and physical diagnostic waxing

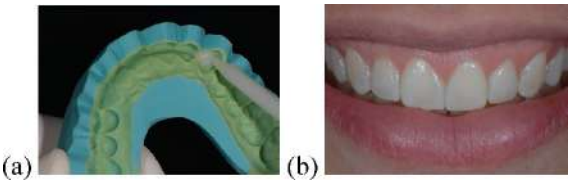

Fig. 8 **a**, **b** Maxillary and mandibular mock-ups made of bis-acryl composite resin (Protemp, 3M ESPE, USA). Positioning of the resin within the silicone guide, which is positioned over the unprepared teeth

Fig. 9 Laboratory-made resin composite restorations on a plaster cast

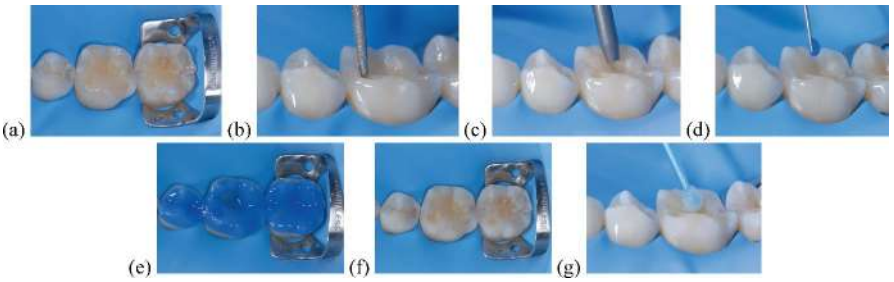

Fig. 10 **a** Absolute isolation with rubber dam. **b** Preparation of teeth. Sharp angles due to wear rounded using diamond bur. **c** Cleaning the tooth with air abrasion. **d–f** Acid etching of teeth. **g** Adhesive resin bonding application

Fig. 11 **a** Air abrasion, **b** cleaning and **c** adhesive resin bonding application to intaglio surfaces of indirect restorations

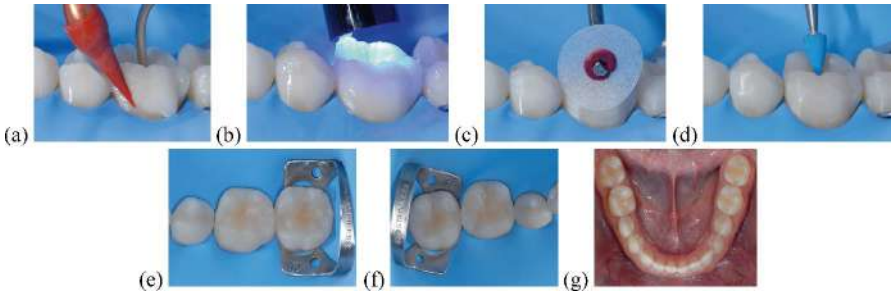

Fig. 12 **a** Excess cement removal with rubber tips and brushes. **b** Photopolymerization from the occlusal, buccal and lingual surfaces. **c**, **d** Finishing and polishing of restorations with finishing disks and rubber tips. **E**–**g** Indirect posterior restorations in situ after adhesive cementation

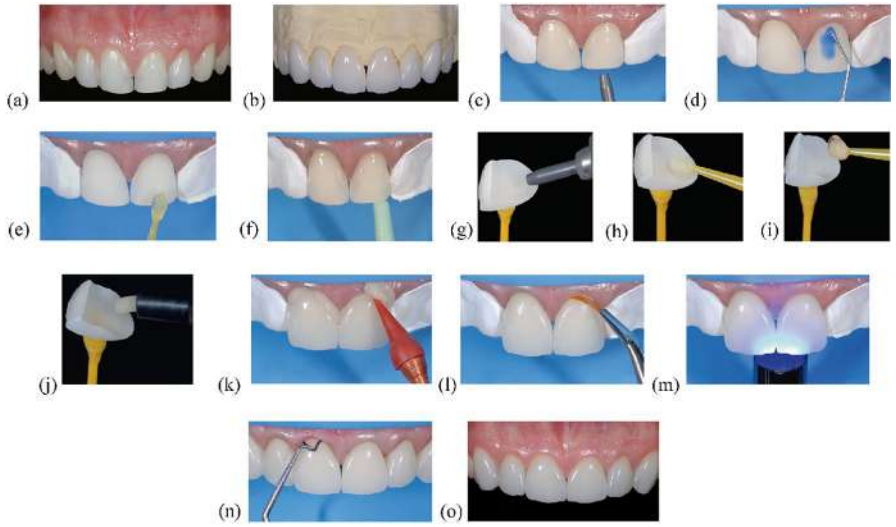

Fig. 13 Ceramic veneers on anterior teeth. **a** Preoperative view of dental preparations. **b** Feldspathic porcelain veneers on plaster cast. **c** Air abrasion of the surface dental preparations with 50 μm Al_2O_3 particles. **d** Total etching of the tooth surface with 37% phosphoric acid (Ultra-Etch, Ultradent) for 30 s. **e**, **f** Adhesive resin bonding application (4th generation, Adper Scotchbond Multi-purpose, 3M ESPE) with a micro-brush and suction of excess adhesive resin. **g**–**j** Air abrasion of the intaglio surface of veneers, conditioning with HF for 120 s, application of silane coupling agent with a disposable brush and waited for 5 min for the evaporation of the solvent, and adhesive resin cement application (NX3, Kerr). **k**, **l** Excess cement removal with rubber tips and fine brushes. **m** Photopolymerization from palatal, incisal and labial surfaces. **n** Removal of retraction cord after photopolymerization. **o** Young patient with moderate dental wear due to erosion and attrition, treated with ceramic veneers on anterior teeth and resin composite indirect posterior restorations

increase in vertical dimension is a determining factor for selection of the restorative material as the material thickness governs the functional performance of the restoration.

In case of adequate interocclusal space, tooth preparation for indirect adhesive restorations should include rounding of sharp angles, particularly in case of treatment-naïve teeth. If prior restorations are present, confirmation of the quality of these restorations is important before tooth preparation. Minimally invasive indirect restorations can be effectively performed due to the availability of CAD/CAM technologies, adhesive luting cements and restorative materials. With the CAD/CAM technology, resistant materials like high-performance hybrid resin or ceramic composites and lithium disilicate-based ceramics can be used to fabricate minimally invasive restorations like veneers as follows (Figs. 6, 7, 8, 9, 10, 11, 12, 13):

- If necessary, the increase in the vertical dimension of occlusion should be made to obtain sufficient space between the teeth. This step allows the use of the existing space due to wear and aids in the removal of small amounts of healthy dental tissues during tooth preparation (Fig. 6). It also facilitates minor alterations in position, anatomy and shape.
- Casts should be mounted on an articulator for diagnostic waxing in the proposed vertical dimension following a detailed clinical examination (Fig. 7). Waxing can delineate the tooth shape, and detect the amount of space available between the teeth and the amount of tooth preparation required.
- Silicone guides should be prepared on diagnostic waxing to develop guides for dental preparation, mock-ups and provisional restorations. Mock-ups should be made before tooth preparation to enable the patient to view the expected final result in the mouth. Mock-ups are made of bis-acryl composite resin (Protemp, 3M ESPE, USA) and aid the clinician to effectively envision the extent of tooth wear (Fig. 8a). This phase of treatment should be allotted adequate time and effort. The diagnostic waxing should be altered, if the mock-up is not acceptable for the clinician and the patient. Selection of the restorative material for fabricating the final restoration and the design of the tooth preparation can be defined only after a satisfactory result of the diagnostic waxing and mock-up (Fig. 8b).
- Thereafter, the indirect restorations should be fabricated in the laboratory (Fig. 9).
- The shade of the luting cement should be selected to prevent change in color of the minimally invasive restoration using try-in cements during clinical trials of the restorations.
- Careful handling of minimally invasive indirect restorations is essential during clinical trials and adhesive protocols because of their low thickness.
- The restorations should be ultrasonically cleaned after clinical trial.

Table 2 Conditioning of vitreous ceramic restorations using HF acid gel

Type of vitreous ceramic	HF gel concentration and application time
Feldspathic ceramic	9.6% HF for 2–3 min
Leucite-reinforced ceramic	5% HF for 1 min
Lithium disilicate-based ceramic	5% HF for 20 s

- Adhesive resin cementation is a critical procedure as it has multiple steps and is moisture-sensitive. Sufficient isolation with rubber dam should be established, whenever possible (Fig. 10a).
- Teeth should be prepared, cleaned and conditioned followed by adhesive resin bonding application (Fig. 10b–g).
- Conditioning of the intaglio surfaces of the restorations should be done as per the specific protocol for each material. HF acid gel should be used to condition vitreous ceramic restorations followed by washing and drying (Table 2).
- The conditioned surface of resin composite restorations should be coated with a layer of silane coupling agent followed by air-drying of the solvent (Fig. 11a, b). A layer of adhesive resin bonding should be applied on the inner surfaces and air-thinned (Fig. 11c). Photopolymerization should not be done to prevent increase of the cement film thickness.
- The adhesive resin bonding applied over the tooth preparation should be photopolymerized for stability of the hybrid layer.
- The restoration should be loaded with resin-based luting cement and placed on the prepared tooth.
- Excess cement should be removed partially prior to photopolymerization to prevent residual cement from breaking or being difficult to remove after polymerization (Fig. 12a).
- As these restorations are translucent and thin, the luting cement can be photopolymerized through the restoration by directing the tip of the polymerization device from the occlusal, buccal, lingual and mesial directions with 2 mm distance to the surface (Fig. 12b).
- The restorations should be finished and polished using finishing disks and rubber tips (Fig. 12c–g).

Conditioning of indirect resin composite or nanocomposite resins restorations should be done as per the manufacturers' instructions. These materials require air-abrasion of the surfaces before the application of adhesive resin bonding to enhance roughness and facilitate chemical adhesion and micromechanical interlocking of the resin cement. Slight resistance to HF etching can be exhibited by nanocomposite materials. In such cases, application of universal bonding agent to the cementation surfaces for 20 s using a micro-brush should be done. Thereafter, adhesive cementation should be carried out in a similar way as for ceramic restorations.

Pitfalls and complications

- Direct resin composites are prone to wear and staining.
- Indirect restorative procedures are associated with higher costs, longer treatment sessions and occasional mechanical failures.
- Minimally invasive indirect prostheses are delicate pieces because of their low thickness. When adhesive procedures are not applied correctly and meticu-

lously or cement shade is not selected appropriately, failures may be experienced.

Further Reading

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