ORIGINAL PAPER

CLINICAL PERFORMANCE OF "FREE-HAND" DIRECT COMPOSITE CROWNS USED FOR THE RESTORATION OF SEVERELY DESTROYED MANDIBULAR MOLARS

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ABSTRACT

Introduction: There are several restorative approaches for the restoration of severely destroyed teeth, each with its own advantages and disadvantages.

Objectives: This study aimed to evaluate the clinical performance of direct composite resin crowns used for restoration of severely destroyed mandibular molars in young patients.

Material and methods: In total 45 severely destroyed vital and non-vital mandibular molars were restored in 44 patients (24-40 years old). Mandibular molars were restored in a "free-hand" direct restoration approach using a biomimetic concept (4-layer technic). After the restoration, on the 3rd- and 6th-month, and the 1st-, 2nd-, and 3rd-year follow-ups, the clinical performance of the restoration was evaluated. During the follow-ups, the integrity of restoration, contact point stability, dental plaque accumulation, and gingival bleeding indices were evaluated, and restoration survival was accessed.

Results: Restorations showed up to 100% survival after 3 years of exploitation. Significantly, lower gingival bleeding and plague accumulation index were registered during the follow-up visits after the restoration, which is a sign of good integration of the restoration into the bite. Only one case of partial fracture of the restoration occurred, which was repaired with composite resin. No differences between the clinical performance in non-vital and vital mandibular molars were observed.

Conclusions: "Free-hand" direct composite crowns used for the restoration of severely destroyed mandibular molars showed promising results for the restoration of severely destroyed mandibular molars in a 3-year observation period.

Key words: caries, adhesive restoration, direct composite restoration, composite crown, destroyed teeth.

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INTRODUCTION

Caries is a dynamic process that occurs on the tooth surfaces and is accompanied by constant demineralization and remineralisation. When the balance between them shifts to demineralization a carious lesion occurs [1]. The prevalence of tooth caries and its complications is still high in all populations and age groups, despite huge progress in the understanding of the pathogenesis of caries, prophylaxis, and high awareness among patients [1-4]. The asymptomatic course of caries in the initial stages leads to severe loss of sound tissue and the development of subclinical inflammation in the tooth pulp, which makes the tooth mechanically weaker and impairs longevity and treatment prognosis [5]. That is why the prevalence of severely destroyed teeth by caries also remains high, especially in young subjects [1, 6, 7]. Caries and its complications lead to rapid sound tissue

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loss and involvement of the tooth pulp in the inflammatory process that requires root canal treatment and makes a tooth even more fragile and weak [8]. All of this makes the decision-making process of restoration management difficult because of the absence of a unitary guideline for the treatment of severely destroyed teeth [9, 10]. There are several restorative strategies for the management of severely destroyed teeth. They are direct, semi-direct, or indirect constructions; however, each technique has its own advantages and disadvantages [11, 12].

Direct composite resin restoration has several advantages compared to the indirect technic. It does not require excessive sound tissue preparation, has sufficient mechanical and functional properties, does not require any additional special equipment or the involvement of a dental technician, takes less time, has the possibility to be repaired in case of minimal fracture or changing of shade, less expensive etc. [13-15]. Minimally invasive and adhesive dentistry strategies in rehabilitation of severely destroyed teeth are crucial, especially for young patients, for whom a comprehensive, lifelong approach is essential.

OBJECTIVES

The aim of the study was to evaluate the clinical performance of restored severely destroyed mandibular molars in "free-hand" direct composite crown technique in young patients.

MATERIAL AND METHODS

ETHICAL STATEMENT

The study was conducted in accordance with the World Medical Association Declaration of Helsinki and approved by the Ethics Committee of Poltava State Medical University (protocol number 1207). All participants gave their informed consent. Restorative treatments were carried out at the Department of Therapeutic Dentistry, Poltava State Medical University.

SAMPLE SIZE

Patients with severely destroyed one side mandibular molar and the presence of tooth antagonists were the target population. Enrolment of patients was carried out between October 2019 and April 2020, and a total of 44 (male and female) patients were enrolled into the study. In total 45 mandibular molars were restored. The inclusion criteria were severely destroyed lower first or second molars with tooth occlusal surface failure index 0.7 or more (by Milikevich *et al.* [16]), which means that more than 70% of the tooth's occlusal surface was destroyed, age between 24 and 40 years, presence of all premolars and first and second molars on the upper jaw (intact or restored with composite resin carious cavities), vital either non-vital teeth, intact periodontium, or the presence of all types of gingivitis or initial stage periodontitis (stage I). The exclusion criteria were absence of severe periodontitis stage II, III, or IV, presence of any prosthetic constructions on the lower or upper dentition except frontal teeth (incisors and canines), presence of removable partial denture, and severe tooth wear.

RESTORATIVE PROTOCOL DESCRIPTION

The biomimetic concept of direct restoration (4-layer technic) was used for the restoration of all severely destroyed teeth in this study, invented by Radlinsky [17, 18]. Before the restoration, a full photo protocol and professional oral hygiene were completed for every patient. After the local anaesthesia administration, tooth preparation was done according to the minimally invasive protocol for adhesive composite restoration [19]. Dentin preparation was done with spherical diamond burs of normal grain size (100-120 μm, burs without marking) or larger granularity (130-140 μm, burs marked with a green ring) (SHOFU Dental GmbH, Japan). Tooth enamel preparation was carried out using spherical diamond burs of fine grain size (50 μm, red marking) and very fine grit (30 μm, yellow marking) (SHOFU Dental GmbH, Japan) using a backlit turbine handpiece with intensive water irrigation. In non-vital teeth, a gutta-percha filler in the orifices was removed during the preparation in order to create a wider adhesive surface. Isolation of the tooth with the rubber dam system was done. Root canal treatment (retreatment), if needed, was performed. Processing of the tooth edges after preparation was done with diamond oval elongated fine-grained burs (SHOFU Dental GmbH, Japan), to remove sharp edges and weakened tissues. Selective etching adhesive protocol was applied, according to the manufacturer's instructions using 36% orthophosphoric acid (Detrey Conditioner 36%, Denstply Sirona, USA) (30 seconds for enamel, 15 seconds for dentin) and Prime & Bond Universal adhesive (Dentsply Sirona, USA), followed by solvent removal – 20-sec polymerization with an LED.D polymerization unit (Woodpecker Medical Instrument Co. Ltd.). Adhesive protocol was completed with the creation of a super-adaptive layer by applying of a thin layer of flowable composite resin SDR flow+ (Dentsply Sirona, USA). A thin layer of flowable composite resin was distributed with a dental probe on all tooth surfaces over the adhesive layer, after which it was polymerized for 20 seconds. The super-adaptive layer topography is shown in Figure 1.

Order of basic tooth construction restoration is shown in Figure 2. The restoration always began with the oral and vestibular surfaces. Then the proximal surfaces were restored, using a hard 0.05 mm sectional matrix (Latus, Kharkiv, Ukraine) fixed with wooden wedge and

a Palodent separation ring (Dentsply, USA) to obtain tight contact. The restoration was performed in the biomimetic layering technique of S. Radlinsky, gradually applying layers of composite "from the inside to the outside". A highly opaque composite resin Esthet-X HD WO (Dentsply Sirona, USA) was used for the imitation of the parapulpal dentin and the projection of the tooth pulp (Figure 1).

Restoration of the main dentin was performed with Spectrum TPH3 A3.5-O (Dentsply Sirona, USA), and for the main enamel of the tooth reproduction – Esthet-X HD A1/A2/A3/B1/B2 (Dentsply Sirona, USA) shades were used, which depended on the shade and colour of the patient's tooth (Figure 1). The superficial enamel layer was restored with Esthet-X HD YE/WE (Dentsply Sirona, USA). The last step was a restoration of the occlusal surface. Each portion of composite resin was polymerized for 15 sec, after ensuring their good adaptation and adhesion to the tooth tissues. After the complete tooth restoration, with a finishing diamond bur polishing (yellow marking) with water irrigation, rough processing of the restoration was done to remove the excess composite material. Polishing of the contact surfaces was done with wide metal strips of medium and then fine grain (GC, Japan) with a wedge inserted into the interdental space, which prevents weakening of the contact point. The area of the tooth below the contact point was polished with a narrow metal polishing strip of medium grit (GC, Japan). After processing of interproximal surfaces, the presence of overhangs and zones of retention were checked with dental floss and then on X-ray image. Then the rubber dam was removed, and the restoration was adapted to the patient's bite using fine-grained diamond burs (yellow marking) (SHOFU Dental GmbH, Japan). For polishing of the restoration, the Enhance finishing system (Dentsply Sirona, USA) was used. For polishing to a dry gloss, a one-step polisher was used (Komet, USA) and an Occlubrush (Kerr Dental, Switzerland). The average time of restoration, without root canal treatment depended on the clinical case and was usually 90 min ± 15 min. Several clinical cases of mandibular molar restoration in free-hand direct composite crown technic are presenting in Figures 3-6.

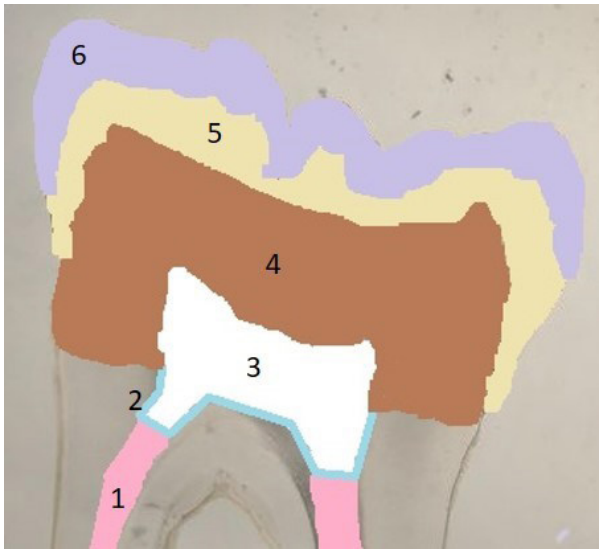

FIGURE 1. Topography of composite resin in restored tooth (1 – root canal filling, 2 – super-adaptive layer, 3 – layer of predentin, 4 – layer of main dentin, 5 – layer of main enamel, 6 – layer of superficial enamel)

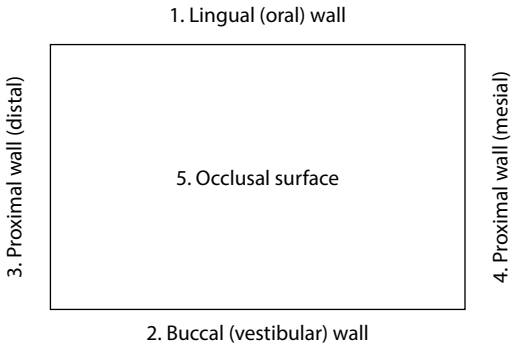

FIGURE 2. Order in which tooth surfaces were repaired to restore a basic tooth construction

FOLLOW-UP

After the tooth restoration, follow-up visits were scheduled at 3, 6, and 12 months and annually thereafter. At each recall, clinical examination was carried out to evaluate the following: survival of restoration, signs of composite resin deboning, gingival inflammation around the restoration, dental plaque accumulation, absence/presence of overhangs on proximal surfaces (assessed by floss test), contact point stability, aesthetic characteristics, presence/absents of fracture, and chips. Before the restoration and during the follow-up visits the plaque accumulation indices and gingival inflammatory indices around the restored tooth (in 4 sites) were evaluated with the BoP (bleeding on probing) index and PI (plague index simplified) and PBI (papilla bleeding index). After each follow-up a professional hygiene procedure of the oral cavity was done for every patient and all composite restorations were polished.

STATISTICAL DATA ANALYSIS

GRAPHPAD PRISM 8.0.1 software was used for data statistical analysis. All results were described as average and standard deviation. For data analysis, we used a one-factor analysis of variance (one-way ANOVA) for unrelated samples and Bonferroni correction for multiple comparisons was done. The difference between groups was considered statistically significant at $p < 0.05$.

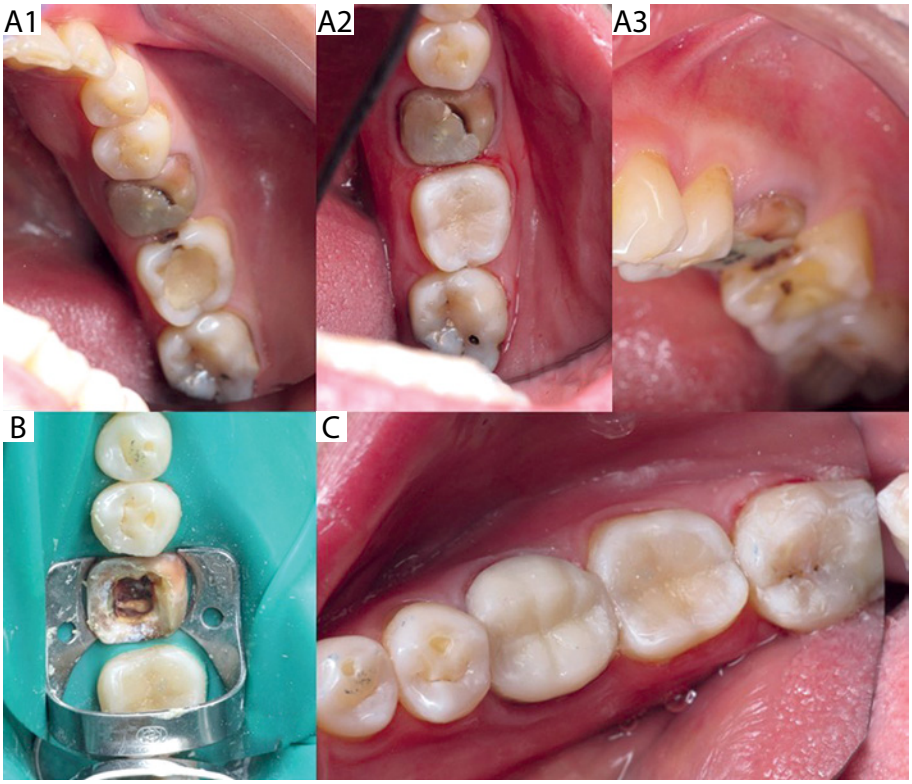

FIGURE 3. Free-hand technique direct composite crown of tooth 46. **A)** (1-3) Tooth 46 before restoration. **B)** Rubber dam placement after the filling and decay removal. **C)** Tooth 46 after the restoration

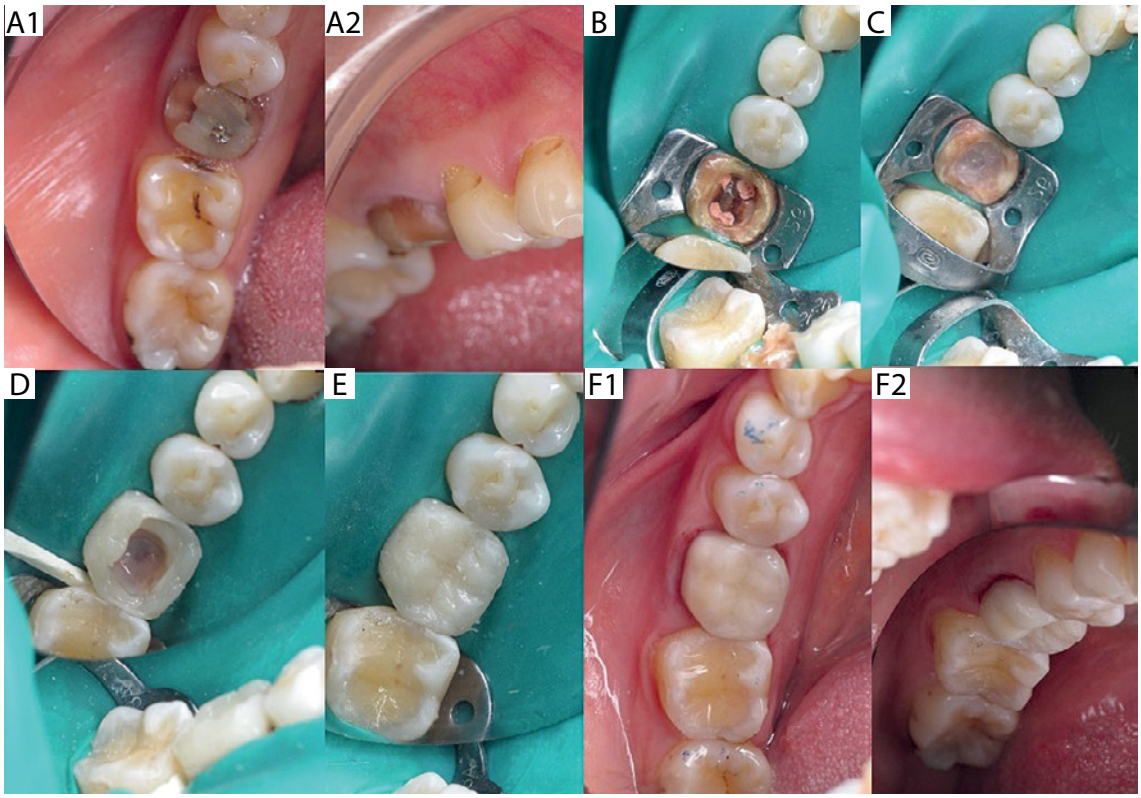

FIGURE 4. Free-hand technique direct composite crown of tooth 36. **A)** (1-2) Tooth 36 before restoration. **B)** After root canals retreatment. **C)** Sealing of tooth base with flowable resin composite. **D)** Tooth 36 wall restoration. **E)** Restored tooth 36 before rubber dam removal. **F)** (1-2) Restored tooth 36 after polishing

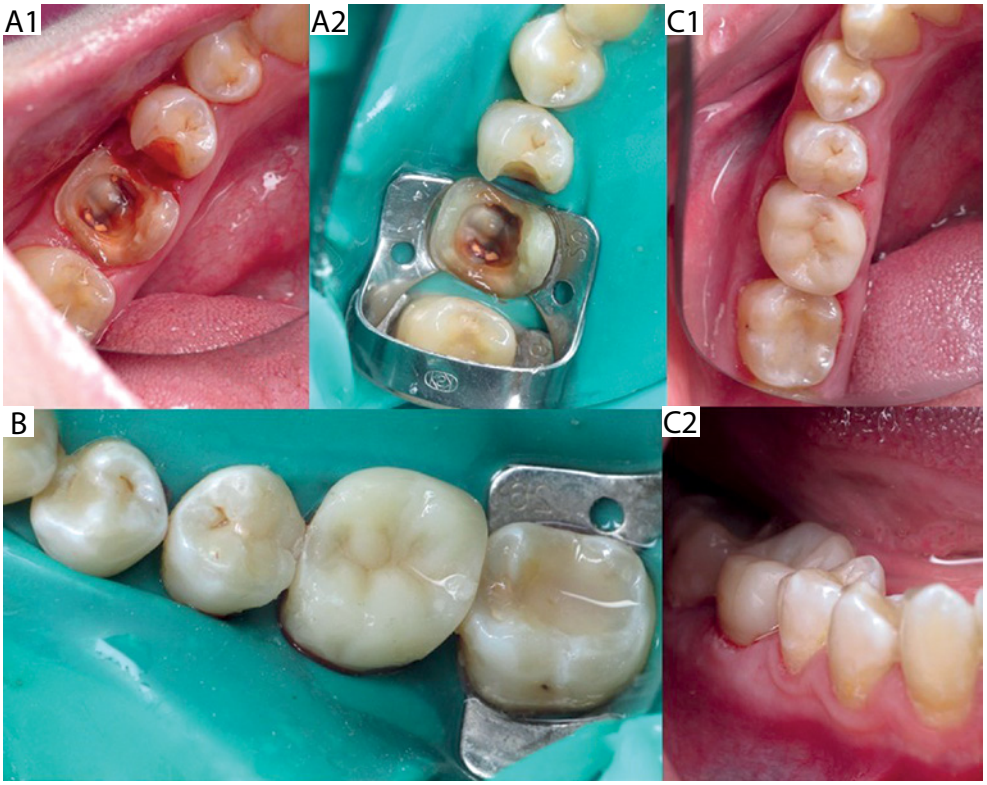

FIGURE 5. Free-hand technique direct composite crown of tooth 46. **A)** (1-2) Tooth 46 and 45 after the old filling and decay removal. **B)** Restored teeth 45 and 46 before polishing. **C)** Teeth 45 and 46 after final polishing

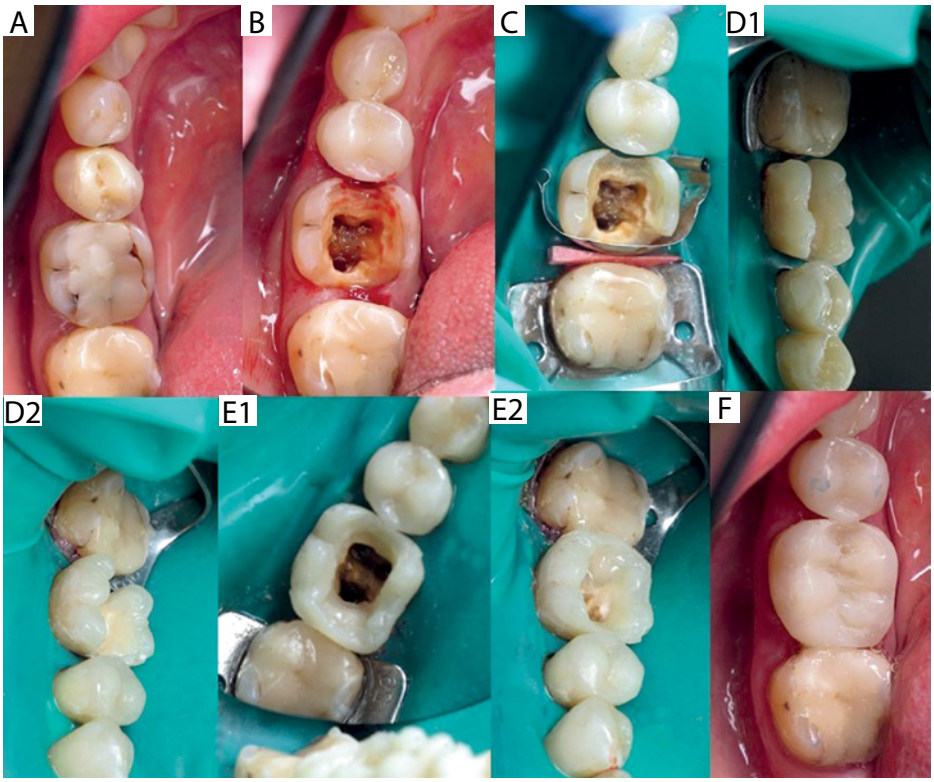

FIGURE 6. Free-hand technique direct composite crown of tooth 36. **A)** Tooth before the restoration. **B)** After old filling and decay removal. **C)** Deep margin elevation. **D)** (1-2) Restoration of vestibular and oral wall. **E)** (1-2) Tooth after the proximal surface restoration. **F)** View of tooth 36 after root canal treatment and complete free-hand composite restoration

RESULTS

A total of 45 mandibular molars were restored in free-hand direct composite crown technic in 44 patients. The population sample included 28 female and 16 male subjects. The average age was 31.5 ± 4.7 years. During the study 7 left and 9 right second mandibular molars, and 13 right and 16 left first molars were restored. Of them, 34 mandibular molars were vital and 11 non-vital.

Three and 6 months after the restoration, no adverse effects were observed in any patient, except loss of tight interproximal contact between teeth 36 and 35 in a 26-year-old male patient, which can be explained by the relapse after orthodontic treatment that caused a protrusion of tooth 35. Significantly lower BoP and PBI were registered after the treatment, compared with initial situation ($p < 0.05$) (Table 1). Restorations show up to 100% survival after 3 years of exploitation (Table 1). In one patient male, 32 years old, who has bruxism, 9 months after the restoration of vital tooth 46, restored with composite resin, a mesiobuccal cusp fracture occurred at night. The restoration was repaired with an adhesive technic by direct composite resin. In 2 patients on the 3rd year of exploitation an overhang of a restoration on the proximal surface occurred, which manifested with dental floss hooking. The overhangs were eliminated during the professional oral hygiene procedure by gentle stripping with a fine-grain metal strip. Teeth that underwent root canals treatment were checked-up by periapical X-ray on the 3rd and 6th month after the treatment. No complications after the root canal treatments were diagnosed. Absence of pain, and a decrease or absence of signs of periapical lesion were assessed as successful treatment outcomes.

DISCUSSION

Radlinsky designed a "free-hand" direct composite crown concept in the biomimetic technique of restoration in late 1990s because of the absence of aesthetic indirect constructions in post-Soviet states, such as CAD/CAM zirconium dioxide, lithium disilicate press ceramic indirect restorations, etc. With the development of adhesive systems and composite materials for direct restoration, the outcomes and clinical performance of restoration became more predictable and long lasting. Modern universal adhesive systems have enough bond strength to dentin and enamel to make it possible to restore even severely destroyed teeth only with direct composite resin in a direct technique [20-22]. However, direct restoration is not so effective in elderly patients because of significantly lower adhesive bond strengths to the sclerotic dentin [23]. The latest nano and hybrid composite resins for direct restoration of anterior and posterior teeth exhibit similar, for natural tooth, mechanical, flexural, compressive, and diametral tensile strength, fracture toughness, and abrasive wear, which makes them suitable for use even in high-stress-bearing areas [24, 25]. This technique has relatively easy reproducibility and requires only a single visit to finish the restorative treatment, compared with indirect restoration, where the patient should wait for several days or months. However, sometimes it is not easy to adjust the restoration during the same appointment, because of numbness after the anaesthetic administration. Hence, in 20% of cases a second appointment is needed to finish the treatment, and in 8.9% of cases, on the second day after the restoration, in teeth that patients felt were high, minor chips occurred, which were eliminated by polishing with the Enhance finishing system (Dentsply Sirona, USA). This restorative method is reasonable for severely destroyed teeth because it preserves the small amount of remaining sound tissues by employing a minimally invasive preparation concept, especially when young patients are involved. Conventional preparation with full-coverage ceramic crowns requires tooth reduction of 40-70%, while minimally invasive protocols preserve dental structure and avoid elective endodontic therapy [26]. We showed that removal of tooth structure decreases fracture resistance, and indirect restorations are not capable of fully restoring tooth resistance, compared with direct restoration [13].

TABLE 1. Clinical performance and result after the restoration of mandibular molars by the direct composite crown in dynamic

Terms	Number of cases	BoP, %	PBI	PI	Contact point stability, %	Survival, %	Adverse event, if it occurred*
Before treatment	All ($n = 45$)	34.4 ± 6.3	0.88 ± 0.52	1.68 ± 0.35	n/a	n/a	n/a
3 months	All ($n = 45$)	2.6 ± 4.3	0.04 ± 0.40	1.90 ± 0.43	97.06	100.00	0
6 months	All ($n = 45$)	2.4 ± 4.6	0.16 ± 0.37	1.24 ± 0.21	97.06	100.00	0
1 year	All ($n = 43$)	1.6 ± 3.7	0.26 ± 0.54	1.10 ± 0.10	95.70	95.70	1 case (cusp fracture)
2 years	All ($n = 41$)	3.2 ± 0.6	0.27 ± 0.04	0.80 ± 0.11	95.12	95.12	0
3 years	All ($n = 28$)	3.3 ± 0.5	0.40 ± 0.09	0.70 ± 0.18	100.00	100.00	2 cases (overhang occurrence)

**Layers of composite resin debonding and major fractures were referred to as adverse events.*
The BoP, PBI, were significantly higher before treatment compared with the follow-up groups ($p < 0.05$).
BoP – bleeding on probing index, PI – plague index simplified, PBI – papilla bleeding index

TABLE 2. Advantages and disadvantages of "free-hand" direct composite crown restorations

Advantages	Disadvantages
• Require minimal sound tissue preparation • Require single visit to complete treatment • No special equipment or dental technician needed • Repairable • Good aesthetic outcome • Less expensive • Similar to natural tooth mechanical properties and wear rate	• Require particular skills for manufacturing • Difficult to restore single teeth, because of the lack of clinical orienteers • Requires polishing to maintain gloss • Not so effective in elder patients with sclerotic dentin and in non-vital teeth

The biomimetic concept that was used for the restoration is very convenient, because it does not require a huge number of direct composite resin shades. In the biomimetic concept of Radlinsky (4-layer technic), teeth of any shade can be restored only with one flowable SDR flow+ (Dentsply Sirona, USA) and 4 universal composites (one microhybrid – Spectrum TPH3 A3.5-O [Dentsply Sirona, USA] and three nanocomposites – Esthet-X HD [Dentsply Sirona, USA]) (Figure 1). Flowable composite SDR flow+ (Dentsply Sirona, USA), composite for predentin restoration Esthet-X HD WO (Dentsply Sirona, USA), and main dentin Spectrum TPH3 A3.5-O (Dentsply Sirona, USA) are unitary for restoration of every shade group: A, B, C, D (VITA classical A1-D4® shade guide) (Figure 1). The only variable is the shade of main enamel, which depends on the patient's natural tooth shade: A1/A2/A3/B1/B2 (Dentsply Sirona, USA) and the superficial enamel layer composite Esthet-X HD YE/WE (Dentsply Sirona, USA). The individual natural tooth hue for each patient, chroma, and value, which form the shade of the restoration, were reproduced by different thicknesses of each composite resin layer. For example, for the restoration of the tooth of the A shade group, a thicker layer of main enamel and thinner layer of superficial enamel were required, and vice versa for group B teeth, where a thinner layer of main enamel and thicker layer of superficial enamel were required.

In 3-year follow-ups mandibular molars restored in "free-hand" direct composite crown technic showed up to 100% survival; our data correspond with similar studies in which the clinical performance of direct posterior composite restorations were studied [24, 27, 28]. No differences between clinical performance in non-vital and vital mandibular molars was observed. Normalization of BoP, PBI, and PI after the restoration attest to good integration of restoration with periodontal tissues. The presence of a tight contact point between nearby teeth prevents food impaction, smoothness and gloss of the restoration prevents plaque accumulation, and proper shape and size of the restoration allows physiological clearance of the restored tooth during mastication, tongue movement, etc. However, "free-hand" direct composite restorations require polishing at least once a year to maintain their gloss, which is performed after each professional oral hygiene procedure. The following approach has several advantages and disadvantages, which are presented in Table 2.

CONCLUSIONS

"Free-hand" direct composite crown in a biomimetic technique, which was used for the restoration of severely destroyed mandibular molars, showed up to 100% survival during the clinical performance in young individuals. There were no differences between vital and non-vital teeth restored with the aforementioned technique. Direct restorations of severely destroyed molars show numerous advantages compared with indirect restorations. They avoid sound tissue overpreparation, require only a single visit to complete the treatment, do not require special equipment, have good aesthetics, and are less expensive.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest concerning the research, authorship, and publication of this article.

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