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Review Article

Clinical management of provisional crowns and bridges on short clinical crowns – A review of current evidences

[1]Yusra Fatima, [2]Banpreet Kaur, [3]Akash Raj Sharma

[1,2]Intern, Department of Oral Medicine and Radiology, Subharti Dental College & Hospital, Swami Vivekanand Subharti University, Meerut, Uttar Pradesh, India;
[3]Department of Prosthodontics and Crown & Bridge, Subharti Dental College & Hospital, Swami Vivekanand Subharti University, Meerut, Uttar Pradesh, India

ABSTRACT:
Short clinical crowns (SCCs) are a common occurrence in daily clinical dental practice. They may be associated with age, gender, race, genetics, or due to environmental conditions. They pose a significant test in restorative dentistry since they affect the retention and resistance of an artificial crown or fixed partial denture (bridge). Digital advances, especially CADCAM (computer-aided diagnosis and computer-assisted machining), have introduced a plethora of new materials and techniques that overcome many of the disadvantages associated with early procedures. This review aims to present the current evidence on these two technologies in the context of managing SCC, with a specific focus on provisional restorations (PR) for single crowns or bridges. The objective is to enhance the practitioners' knowledge and comprehension of the biomechanical aspects involved in restoring lost or missing natural teeth.
Key words: short crowns, crown root ratio, polymethylmethacrylate resin, composite resin, three dimensional printing, milling

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Corresponding author: Yusra Fatima, Intern, Department of Oral Medicine and Radiology, Subharti Dental College & Hospital, Swami Vivekanand Subharti University, Meerut, Uttar Pradesh, India

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INTRODUCTION

Even though implant-supported prostheses have revolutionized tooth replacement in dentistry, fixed dental prostheses remain the most common restorative technique. After occlusal and axial reduction, a tooth is considered to have a short clinical crown if the remaining sound, parallel walls are less than 2 mm.[1] Short clinical crowns (SCC) are common due to various factors such as genetic disparities, disease, trauma, iatrogenic dentistry, eruption disharmony, and eruption pattern in tooth form.[2,3] Due to reduced retention and resistance, SCC requires additional design features for tooth preparation, which are primarily influenced by surface area, height, axial wall convergence, surface texture, and intracoronal retentive devices.[4] These auxiliary features may include retentive grooves, proximal boxes, and pins, the placement of each varying depending upon the paths of insertions and removals. The limiting extent of each preparation cervically is the gingival epithelium, which is clinically defined by the biologic width. The average biologic width is calculated by dividing the length of epithelial attachment by the length of connective tissue epithelial attachment, resulting in an average of 2 mm.[5] Deep subgingival restorations and their margins can encroach on biologic width, thus posing a threat to periodontal tissue. Mechanical failures (crown dislodgement, fractures) account for 69.5% of fixed cast restoration failures, while biological factors like caries and supporting tissues contribute to 28.5%.[6] Premature crown dislodgment is caused by factors like core structure loss, luting agent failure, inadequate preparation, and not following the manufacturer's directions for involved materials. Short clinical crown retention is a clinical concern that, when learnt, becomes a potent skill at both undergraduate and postgraduate levels.[7, 8] Restoring a natural tooth with SCC involves alterations in tooth preparation design, placement of foundation restorations, surgical crown

lengthening, orthodontic eruption, and endodontic treatment, and finally a substitute treatment in the form of a removable partial denture.[9] The crown-to-root ratio determination during diagnosis and treatment planning is an important parameter that must be calculated through proper analysis. [10]The requirement of such a parameter will vary depending upon the type of fixed partial denture design, like a cantilever or a spring fixed partial denture.[11,12] Provisional restorations (PR) [temporary crown, temporary bridge] play a crucial role in determining the therapeutic effectiveness of treatments like complete occlusal rehabilitation,[13] anterior teeth crown lengthening,[14] bone augmentation, and progressive implant loading. In implants, PR enhances the well-being of abutments and periodontium, guiding tissue healing for a suitable emergence profile.[15]

Food and Drug Administration (FDA)-approved provisional restorative materials include bisacryl and light-cure composite resin, polyethylmethacrylate, and polymethyl methacrylate (PMMA), which have been used based on different clinical techniques.[16] However, PMMA still has issues like exothermic polymerisation and inaccuracy. Digital manufacturing, which involves computer organisation, has reduced these drawbacks.[17] The introduction of additive and subtractive (3D) printing with new materials has led to the development of affordable 3D printing machines in private clinics and dental laboratories.[18] Milled PRs have improved mechanical properties, accuracy, faster technology, and reduced costs. This review was therefore considered necessary to update the knowledge regarding various PR materials, techniques, failures, and managing these failures. A medical database search was conducted across PubMed, Scopus, Web of Science, Google Scholar, and other indexed websites. Related literature was identified related to provisional restorations, fixed partial dentures, SCC, and failures in fixed partial dentures. The literature was organised under the below-discussed headings and subheadings.

Retentive features in tooth preparations: Studies have found that posterior teeth preparations had higher total occlusal convergences (TOC) than anterior teeth, and molars had the highest TOC. Facial/lingual surfaces were more convergent than mesial/distal surfaces, and fixed partial denture abutments had higher TOC than individual crowns. Maxwell et al. found that 3 mm is the minimum occluso-cervical dimension needed for crowns for maxillary incisors/mandibular premolars with minimal TOC, and teeth without these dimensions should have additional retentive and resistance features.[21] Research indicates that the placement of interproximal auxiliary preparation features (groove/box) in tooth preparations increases their resistance, with grooves in interproximal locations offering more resistance than buccal or lingual locations.[22, 23] Full coverage cast preparations should have 10-20° convergence occlusally, with at least 4 mm height for a molar and 3 mm for other teeth, with 16° as the optimal convergence angle.[24] To provide a circumferential measurement of the amount of sound tooth structure, use a periodontal probe. The recommended measurements are as follows: 5 millimetres coronal to the alveolar crest, 2 millimetres for biologic breadth, 1 millimetre for sulcular depth, and 2 millimetres for minimal retention and resistance form.[25]Chan and Boyer et al. proposed the concept of auxiliary retention in dental crowns by placing opposing grooves in the castings and cavity, perpendicular to the withdrawal path.[26] These grooves are occupied with cement after cementation, and to dislodge the casting, a break of cement or dentine must occur. Previous studies have found that placing horizontal circumferential groove in the internal surface of complete cast crowns increases retention for optimal tooth preparations, but too much taper may decrease retention and cement failure. Al Shaarani et al. advocated for grooves to improve retention in cast crowns, resulting in 100% retention.[27] Auxiliary retentive methods are used to overcome retention issues in short teeth, such as bridge molars, abutments with over 20 degrees convergence, and teeth less than 3 mm in length to anterior teeth.[28] Ching and Wilson found that adding vertical grooves to tooth preparation increases surface area and resistance form.[29]Tooth preparations that have a total convergence of twenty degrees, such as grooves, boxes, and occlusal isthmuses, do not strengthen the resistance to dislodgement when they are positioned at the same angulations of twenty degrees as the axial walls.[30]In vitro studies show that placing cement keys, grooves, and opposing cement keys in a crown and tooth can increase crown resistance.31 Clinical preparations that are shorter, tooth foundations that are not strong enough, and preparations that are 20 degrees or more shift the cement interface from compression to shear, which therefore increases the likelihood of cohesive fracture.[31] previous studies indicate that a mean TOC angle ranges from 12.2 to 27 degrees, with recent research suggesting a range of 10 to 22 degrees.[32, 33]

Provisional Cementation and surface roughness: A study found that height and height-to-width ratio positively correlate with retention strengths, while surface area alone doesn't improve retention.[33] The dimensions and design of the abutment shape are critical, with height and taper increasing retention. Surface roughness also plays a role, with a roughened tooth surface increasing retention in natural dentition.[34] No biocompatible cement, according to Shillingburg et al., can hold a restoration in place just through adhesion.[33] The shape of the preparation compresses the cement to achieve the required retention and resistance. Cements that are stronger in tension, like resin cements, gain their primary

retention from the surface roughness present on the restoration and on the dentin.[35] Restoration cement should have strong physical properties to resist functional forces and oral degradation, adhering to the underlying dentin.[36] It interacts with tooth structure and crown substrates to create bonds. Retention depends on the geometric form of the tooth preparation. Inadequate clinical crown length and tooth destruction before treatment are the main reasons for restoration failures.[37] A new generation of resin cements has been added to improve retention rates.[35,37] When choosing a provisional FPD cement, consider factors like retrievability and risk of decementation. Use a weak luting agent initially and gradually increase strength in case of decementation. To reduce restoration retention, apply petroleum jelly on the abutment before using non-eugenol resin-based temporary cement. This cement requires the lowest force to decement at 31.6 N, while non-eugenol resin-based temporary cement without petroleum jelly requires 131.6 N of force.[38] Several authors agree that a 20-40 μm cement space is optimal for full crown seating.[39] A study found that most dental cements, including resin cement, adhere to ISO standards for film thickness below 25 μm.

Three dimensional printing and milled provisional restorations: Affordable three-dimensional (3D) printing devices have been developed for use in private clinics and dentistry laboratories in response to the cost-unstable nature of computer-assisted diagnostic and computer-assisted machining (CADCAM) clinical arsenals.[40] The mechanical qualities of milled provisional restorations have been found to be better, whereas additive provisional restorations have been found to be more cost-effective, have quicker technology (provisional crown within 15 to 20 minutes), and replicate the occlusal anatomy more accurately. Denture bases and provisional resins made using CADCAM and 3D printing have had their optical characteristics that affect colour stability researched. The researchers Al Dwairi et al. found that out of three different brands of printed resin tested against heat-cured PMMA resin, the one from Asiga Dentamodel in Alexandria, Australia, had the smoothest surface (0.19 ± 0.03 μm).[41] Of the three types of PMMA tested by Di Fiora et al., bacterial adherence was shown to be lowest on CADCAM specimens both before and after polishing.[42] The other two types of PMMA were heat polymerised and 3D-printed. Newer research has provided strong evidence that milled PMMA denture base resins retain their colour for an extended period of time.[43,44] There has also been research into the colour stability, mechanical and optical characteristics, and related issues of milled and 3D-printed provisional PMMA resin. The higher colour stability after 7 days was found by Elagra et al.[45] for milled provisional PMMA resin. Milled and printed provisional PMMA resin exhibit colour stability for a duration of 8 weeks, following which they undergo rapid deterioration, as described by Song et al.[46] After researching 3D printer optimisation, Tahayeri A et al. came to the conclusion that printer orientation and print thickness optimisation and calibration are crucial for accurate 3D printing. He went on to say that the pre-optimisation of the printing material by 3D printers determines the final qualities of the temporary restorations.[47] When it comes to 3D printing, the colour of the resin ink is just as important as the material itself. For deeper curing, darker inks need to be adjusted to a higher light intensity, while completely translucent materials don't require any optimisation at all. Interestingly, research comparing milled PMMA provisional resins to 3D-printed resin has not optimised the 3D printing process or used pre-programmed settings. In light of new information, subsequently reported properties of milled PMMA provisional resins, such as increased surface hardness,[48] decreased water sorption and solubility,[49] and reduced porosity,[50] warrant additional research into their suitability for long-term provisional restorations.

Clinical relevance: Airborne-particle abrasion significantly increases cement retention. A study found that 20 mm TOC and 8 mm occlusocervical height provided more retention for all tested cements. Thermal cycling, which occurs at temperatures from 5 to 55°C, can also affect the retention of provisional luting agents in clinical settings. A hundred cycles from 5 to 55°C significantly decreased restoration retention.[34] However, when grooves or boxes were added to preparations that had a conversion of 20 degrees or more, the researchers discovered that there was no statistically significant difference in retention, and the increase in surface contact was too tiny to demonstrate any improvement.[51] When the alveolar bone is severely resorbed in the edentulous areas adjacent to the abutment teeth, either the addition of gingival porcelain or a removable partial denture should be considered.[52] gingival retraction procedures should be utilised to expose the subgingival margins whenever an SCC is encountered in daily practice.[53] The internal fit of a PR is more significant for the retention of long-term temporary restorations. In 2016, studies comparing interim crown fit made using conventional compression mould, photopolymer printing, and milling found that 3D printing yielded the most accurate results.[54] Additionally, 3D printing showed better fit values than conventional techniques, CAD/CAM milling, and DLP 3D printing methods. Overall, 3D printing was found to be superior in these studies.[54] 3D printing, an additive technique, produces fewer internal variations in PMMA interim dental crowns compared to subtractive CAD/CAM procedures.[55] With the positive contact area in grooves and interproximal boxes, crown alterations increase the gap or loss of adaption between the die and crown. grooves and interproximal boxes are also

affected. The reason for this reduced internal adaptation is unknown. Thermocycling does not diminish the excellent colour and colour-related qualities (surface roughness, water sorption, microhardness) of moulded PMMA resin.

Patient related factors: Temporary crowns can be destructive to the periodontium since they are usually rough and harbour plaque and bacteria around the gingival sulcus. PMMA-based PRs leach monomer, which can further increase the irritation to the gingiva. [56] patients should receive very exhaustive and elaborate instructions regarding gingival health maintenance whenever provisional crowns or bridges are given for a long time. The instructions regarding oral hygiene maintenance are many and complex, [57]and can be given in written, audio, or video format. [58] All crowns and bridges should be self-cleansing with particular emphasis on the embrasures (gingival and occlusal). Narrow and short embrasures are more likely to be developed during all-ceramic bridge manufacture, where the connector thickness is fixed.[59] Anatomical variations within a tooth and their malformations like fused teeth alter the embrasure anatomy significantly.[60]

CONCLUSION

Irrespective of the advances in crown and bridge restorative materials and new innovative digital fabrication techniques, the majority of the evidence points biomechanical principles of tooth preparations to still determine the retention and resistance form of SCCs in daily clinical practice. The TOC being one of the most important factors that substantially reduces the retention and resistance of a provisional restoration manifold. Therefore, this review recommends clinicians and students to develop skills in tooth preparation rather than rely on materials for the longevity of crowns and bridges.

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