Clinical outcomes of single crown restorations fabricated with resin-based CAD/CAM materials

Futoshi Komine1), Junichi Honda1), Kosuke Kusaba1), Kei Kubochi1), Hiroki Takata1), and Masanori Fujisawa2)

1) Department of Fixed Prosthodontics, Nihon University School of Dentistry, Tokyo, Japan
2) Division of Fixed Prosthodontics, Department of Restorative & Biomaterials Sciences, Meikai University School of Dentistry, Sakado, Japan

Abstract: Computer-aided design/computer-aided manufacturing (CAD/CAM) restorative materials have been widely used owing to a number of advantages, including stable quality of the materials, lower costs, and time-saving factors. Resin-based CAD/CAM materials for definitive restorations are classified into two groups: dispersed nanoparticle-filled composite resin and polymer-infiltrated-ceramic-network materials. Resin-based CAD/CAM materials have been applied to single crown restorations as a monolithic structure for the posterior region. In addition, resin-based CAD/CAM restorations have been applied recently for the anterior area. This literature review summarizes clinical outcomes, such as survival rates and clinical complications of single crown restorations fabricated with resin-based CAD/CAM materials.

Keywords; CAD/CAM, clinical result, fixed restoration, resin material

Introduction

Computer-aided design/computer-aided manufacturing (CAD/CAM) restorative materials have been widely used owing to a number of advantages, including stable quality of materials, lower costs, and time-saving factors. Resin-based CAD/CAM materials for definitive restorations are classified into two groups, as shown in Table 1 [1,2]. Dispersed nanoparticle-filled composite resin contains a polymeric matrix and a filler of nanosized ceramic particles. Polymer-infiltrated-ceramic-network (PICN) materials consist of a ceramic network, which is infiltrated with a polymer. The resin-based CAD/CAM materials provide a superior modulus of elasticity, higher loading capacity, and favorable milling properties compared with ceramic materials [3,4], and have been applied to single crown restorations as a monolithic structure for the posterior region [2]. Due to development of resin-based CAD/CAM materials, these materials are currently applied for anterior single crown restorations. However, the clinical performance of single crown restorations fabricated with resin-based CAD/CAM materials has not been clarified. The aim of this literature review is to evaluate clinical outcomes, including survival rates and clinical complications of the single crown restorations fabricated with resin-based CAD/CAM materials.

Materials and Methods

The questions addressed in this literature review are as follows.

1. What are the survival rates and clinical complications of single crown restorations fabricated with resin-based CAD/CAM materials?

2. Are there any differences in survival rates and clinical complications with the type of resin-based CAD/CAM materials used?

An electronic literature search in the databases PubMed, Web of Science, and Cochrane Library was conducted in March 2020. The search strategy was applied with MeSH terms, including the following keywords: “CAD/CAM”, “composite resin”, “clinical study”, and “case reports”.

Furthermore, additional literature was hand-searched in relevant journals for this review. Literature in languages other than English was verified and translated if necessary. Two reviewers (JH, KK) independently electronically and manually searched the literature.

The titles and abstracts of the articles were initially screened to select the literature based on possible inclusion criteria by the two independent reviewers (JH, KK). According to the selection, full-text analysis was performed to screen the relevant articles. Any disagreements were resolved by discussion. All reviewers were involved in data extraction and assessed the eligibility of the selected full-text articles.

Results

A flowchart of study selection is presented in Fig. 1. A total of 295 articles were identified by initial screening. After discarding duplicates, 250 articles remained. Articles were reviewed by titles/abstracts, and 12 articles were selected in the full-text screening. Finally, a total of 10 articles were included in the present review. The characteristics of the 10 articles are summarized in Table 2 [5-13]. The articles were published between 2010 and 2019. Two articles are prospective cohort studies, two studies are randomized clinical trials, one study is a retrospective cohort study, and the rest are case reports.

Prospective cohort studies, a randomized clinical trial, and a retrospective cohort study showed survival rates of 87.9-97.9% after observation periods from 2 to 5 years for resin-based CAD/CAM restorations (Table 2) [5,9,13]. On the other hand, a randomized clinical trial revealed that the uncompromised survival rate of the resin-based CAD/CAM restorations was 14% at one-year clinical observation [10].

A study by Vanoorbeek et al. [5] showed a total of 29 technical complications, which included 17 cases of restoration loosening, 5 cases of excessive occlusal wear of layering materials, 4 fractures, 1 case of unacceptable color, 1 perforation of layering material due to wear, and 1 probe hooking. Chirumamilla et al. [9] reported 5 cases of rough surface textures, 2 slight color mismatches, and 1 noticeable catch in 36 single restorations using the California Dental Association (CDA) clinical criteria. A randomized clinical trial revealed that debonding between resin-based CAD/CAM restorations and zirconia abutment were seen in 80% of the cases assessed [10]. In addition, catastrophic failure of restorations occurred in 6%. A retrospective cohort study exhibited a relatively high rate of loss of crown retention (12.8%) as the most frequent complication [13].

Discussion

This literature review was designed to assess the clinical outcomes of resin-based CAD/CAM single crown restorations with regard to survival rate and clinical complications. It focused on clinical results that included resin-based CAD/CAM materials, but not traditional composite resin materials.

The results indicate that resin-based CAD/CAM restorations supported with teeth have a favorable short-term survival rate. In addition, the type of the resin-based CAD/CAM materials did not influence the survival rate. A randomized clinical trial compared the 3-year survival rate of resin-based and ceramic restorations fabricated with CAD/CAM blocks and exhibited no significant difference in the survival rates [5]. In addition, the other studies showed potential survival rates ranging from 89.0% to 97.9% for 2-5 years of observation (Table 2) [9,13]. However, the success rate of...
resin-based CAD/CAM restorations (55.6%) was significantly lower than that of ceramic CAD/CAM restorations (81.2%) [5]. Implant-supported resin-based CAD/CAM restorations on zirconia abutments have an inferior survival rate and should not be recommended for clinical use [10]. The authors presume that high stress concentrations occurred in the adhesive interface due to high occlusal stress on implant-supported prostheses, which are absent in the periodontal ligament around the osseointegrated implants. On the other hand, the disparity of the results could be due to the different restorative connection, which was screw-retained fixed partial dentures in the randomized trial study [10].

As a technical complication, loosening of the restorations was frequently observed in the studies included in this review [5,9,10,13]. This may have a number of possible explanations. One possible reason is the large die spacing of the restorations, which results from machine milling with a relatively large diameter of the bars [5,13]. Another possible explanation is that the luting procedure, using adhesive luting agents, is technically demanding and could affect bonding performance. In addition, the resin-based CAD/CAM materials are pre-fabricated and completely polymerized by the manufacturer, which means a poor oxygen-inhibited layer is present on the surface of the materials [14]. Moreover, several studies indicated that the hoop stress that originated at the circumference of the restorations with occlusal forces led to the loosening of the restorations [9,15]. Fracture failures of the restorations were also observed as a technical complication [5,10,13]. As stated above, the large die spacing and adhesive procedure are also likely to involve the fractures of restorations.

To overcome the loosening or fracture of the restorations, adequate occlusal tooth reduction (>1.5 mm) for posterior resin-based CAD/CAM restorations is recommended. In addition, appropriate adhesive procedures are essential to achieve the stability of resin-based CAD/CAM restorations, which is necessary to strongly combine the restorations and abutment teeth. To obtain a strong resin bond, the dispersed nanoparticle-filled composite resin (i.e. Lava Ultimate) should be pretreated through airborne-particle abrasion with alumina particles, followed by application of silane [2,16-18]. On the other hand, the resin infused ceramic hybrid (i.e. VITA Enamic) should be applied with hydrofluoric acid etching and then silanized [2,16-18]. This difference in the adhesive procedure is due to the composition of the resin-based CAD/CAM materials (Table 1).

Occlusal wear of the resin-based CAD/CAM restorations was observed at a relatively high rate in the posterior area [5,9]. It is known that clinical wear of resin-based materials is higher compared with ceramic materials and dental alloys [19]. However, the clinical wear of the resin-based restorations does not directly interfere with the clinical long-term results of the restorations [19]. A review article suggested that recent resin-based materials, such as dispersed nanoparticle-filled composite resin and resin infused ceramic hybrid, have lower wear values than hybrid composite resin materials [20].

The present literature review shows that the resin-based CAD/CAM restorations supported with teeth have a favorable short-term survival rate. The loosening or fracture of the restorations was observed as the main technical complication. Further development of resin-based CAD/CAM materials will increase the long-term clinical stability of the restorations and expand the application range. To date, however, there are no long-term clinical data for resin-based CAD/CAM restorations.

### Table 1: Classification of resin-based CAD/CAM materials

| Classification | Definition | Example of material |
|----------------|------------|---------------------|
| Dispersed nanoparticle-filled composite resin | A polymeric matrix and a filler of ceramic nanoparticles. The composite blocks are dispersed nanofiller materials with a UDMA-based matrix. | Katana Avencia Block (Kuraray Noritake Dental), Cerasmart (GC), Lava Ultimate (3M ESPE), Shofu Block HC (Shofu), Estelite Block (Tokuyama Dental), etc. |
| Resin infused ceramic hybrid | PICN material (Polymer-infiltrated-ceramic-network material). A hybrid structure with two interpenetrating networks of ceramic and polymer. | VITA Enamic (VITA Zahnfabrik) |

![Fig. 1 Flowchart of study selection](image-url)
Table 2  Summary of the characteristics of the included studies

| Author/Year | Study type          | Sample size | Region | Follow-up period | Survival rate | Complication               | Resin-based material | Luting agent             |
|-------------|---------------------|-------------|--------|------------------|---------------|-----------------------------|----------------------|-------------------------|
| Vanoorbeek S et al. 2010 [5] | Randomized trial   | Composite: 59 | Composite: 59 | 3 years  | Composite: 87.9% | Technical complication | Composite: Coping: Composite resin (GC) | Linkmax (GC) |
|            |                     | Ceramics: 141 | Composite: 59 | 3 years  | Ceramics: 97.2% | Coping: Composite resin (GC) | Veneer: GC Gradia (GC) | Ceramics: Coping: Aluminum-oxide ceramic (GC) |
|            |                     | Anterior: 19 | Premolar: 24 | 3 years  | Anterior: 19 | Technical complication | Veneer: GC Initial AL (GC) | Variolink II (Ivoclar Vivadent) |
|            |                     | Molar: 16    | Premolar: 62 | 3 years  | Molar: 16 | Ceramics: 97.2% | Veneer: GC Gradia (GC) | Ceramics: Coping: Aluminum-oxide ceramic (GC) |
|            |                     | Ceramics: 65 | Premolar: 24 | 3 years  | Ceramics: 97.2% | Ceramics: 97.2% | Veneer: GC Initial AL (GC) | Ceramics: Coping: Aluminum-oxide ceramic (GC) |
|            |                     | Molar: 14    | Premolar: 24 | 3 years  | Molar: 14 | Ceramics: 97.2% | Veneer: GC Gradia (GC) | Ceramics: Coping: Aluminum-oxide ceramic (GC) |
| Dirksen C et al. 2013 [6] | Case report      | 15           | Premolar: 24 | 6 months | 100%          | -               | VITA Enamic (VITA Zahnfabrik) | - |
|            |                     | Maxillary: 3 | Mandibular: 4 | 6 months | Maxillary: 3 | VITA Enamic (VITA Zahnfabrik) | - |
|            |                     | Molar: 4     | Mandibular: 4 | 6 months | Molar: 4 | VITA Enamic (VITA Zahnfabrik) | - |
|            |                     | Maxillary: 4 | Mandibular: 4 | 6 months | Maxillary: 4 | VITA Enamic (VITA Zahnfabrik) | - |
| LeSage B 2014 [7] | Case report      | 1            | Maxillary left central incisor | - | - | - | Lava Ultimate (3M ESPE) | RLA |
| Peampring C 2014 [8] | Case report      | 10           | Anterior: 6 | 6 months | - | - | Lava Ultimate (3M ESPE) | Rely X Unicem (3M ESPE) |
| Chirumamilla G et al. 2016 [9] | Prospective cohort | RMGI: 14 | Premolar: 2 | 2 years | RMGI: 92.9% | Technical complication | VITA Enamic (VITA Zahnfabrik) | FujiCem (GC), Breeze (Pentron) or G-Cem Link (Ace (GC)) |
|            |                     | RLA: 31      | Maxillary: 2 | 2 years | RLA: 96.8% | Biological complication | VITA Enamic (VITA Zahnfabrik) | FujiCem (GC), Breeze (Pentron) or G-Cem Link (Ace (GC)) |
| Schepke U et al. 2016 [10] | Randomized trial | 50           | First molar: 15 | 1 year | 14% | Debonding: 80% Fracture: 6% | Lava Ultimate (3M ESPE) | Rely X Ultimate (3M ESPE) |
|            |                     | Mandibular: 2 | Mandibular: 8 | 1 year | Mandibular: 2 | Debonding: 80% Fracture: 6% | Lava Ultimate (3M ESPE) | Rely X Ultimate (3M ESPE) |
|            |                     | Molar: 18    | Mandibular: 17 | 1 year | Molar: 18 | Debonding: 80% Fracture: 6% | Lava Ultimate (3M ESPE) | Rely X Ultimate (3M ESPE) |
|            |                     | Mandibular: 7 | Mandibular: 4 | 1 year | Mandibular: 7 | Debonding: 80% Fracture: 6% | Lava Ultimate (3M ESPE) | Rely X Ultimate (3M ESPE) |
| Demirel A et al. 2017 [11] | Case report      | 1            | Primary second molar | 3 years | - | - | Lava Ultimate (3M ESPE) | Adhesor Carbofinish (Sipofa Dental) |
| Duno D et al. 2018 [12] | Case report      | 1            | Mandibular first molar (implant-supported) | 1 month | - | - | Lava Ultimate (3M ESPE) | Multilink hybrid abutment cement (Ivoclar Vivadent) |
| Christensen G (Clinicians Report 11, 1-3, 2018) | Prospective cohort | - | - | 5 years | 95.0% | - | Lava Ultimate (3M ESPE) | RLA |
|            |                     | - | - | 2 years | 97.0% | - | Lava Ultimate (3M ESPE) | RLA |
|            |                     | - | - | 4 years | 89.0% | - | Lava Ultimate (3M ESPE) | RLA |
| Miura S et al. 2019 [13] | Retrospective cohort | 517 | Premolar | 3 years | 97.9% (Non-RPD abutment) | Loss of retention of crown: 60 Fracture of crown: 7 | Lava Ultimate (3M ESPE) | Fuji I (GC) |
|            |                     | - | - | 3 years | 97.9% (Non-RPD abutment) | Loss of retention of crown: 60 Fracture of crown: 7 | Lava Ultimate (3M ESPE) | Fuji luting EX (GC) |

RLA, resin luting agent; RMGI, resin-modified glass-ionomer cement; RPD, removal partial denture

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Conflict of interest
No potential conflict of interest was reported by the authors.

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