Single-tooth replacement in the anterior maxillary area presents the ultimate esthetic challenge.\(^1\) Although a single-tooth implant-supported restoration does not necessitate preparation of abutment teeth,\(^2\) the implant approach is sometimes impossible and restricted because of accessibility to the bone volume at the inclusion site and the risk factors related to participants, such as smoking, radiotherapy, anxiety, occlusal function, and economic costs. Moreover, the clinical life span of single-tooth implant-supported restorations following 5 years of clinical follow-up extended from 91% to 96.3%\(^3,4\) and 89.4% after 10 years.\(^4\)

The main advantage of resin-bonded fixed dental prostheses (RBFDPs) over full-coverage fixed dental prostheses (FDP) is that they require minimally invasive tooth preparation on the lingual and proximal surfaces. Additional advantages include the supragingival margins and reduced cost due to decreased chairtime.\(^5-7\) In 1991, a design similar to that of metal-ceramic RBFDPs with ceramic wings was introduced to overcome the esthetic drawbacks of conventional metal-ceramic RBFDPs.\(^8\) Unfortunately, early reports about the durability of the two retainers showed connector fractures in one-third of the restorations during the first year of clinical service.\(^9-15\) The ceramic fracture was mainly related to the propagation of a crack through one connector (between the retainer wing and the pontic), leaving the pontic...
attached as a cantilever restoration to one remaining on the abutment tooth. Surprisingly, the fractured restoration continued in function as a cantilever FDP over the 5 years of clinical evaluation.15–17

A 10-year clinical follow-up study of single-retainer and two-retainer FDPs reported clinical endurance rates of 94.4% and 73.9%, respectively.18 Saker et al demonstrated that the clinical durability rates of cantilever metal-ceramic and all-ceramic RBFDPs were 100% and 95%, respectively, after 5 years of clinical evaluation.19

The objective of this retrospective study was to assess and compare the 10-year clinical retention and survival rates of cantilever RBFDPs made of metal-ceramic and glass-infiltrated alumina ceramic. The null hypothesis tested was that both the clinical retention and survival rates of cantilever RBFDPs would not be affected by the type of restoration, whether metal-ceramic or all-ceramic, following 10 years of clinical observation.

MATERIALS AND METHODS

Between August 2007 and December 2009, a total of 40 patients (22 women, 18 men, mean age 36.1 years) missing either a maxillary central or a lateral incisor were recruited into the study and followed up until July 2018. The treatment modalities of single-tooth replacement were discussed with the recruited patients at the Prosthodontics Clinics, Faculty of Dentistry, Mansoura University. Before commencement of the procedure, the participants signed an informed consent form. The study was approved by the ethics committee of Faculty of Dentistry at Mansoura University (A 03030919). The participants were recruited consecutively based on the following inclusion criteria:

- Participant’s age had to be at least 18 years.
- No clinical symptoms of bruxism.
- Participants had to have good oral hygiene status without any active pulpal or periodontal diseases.
- The clinical crown of the abutment tooth had to be of sufficient height for bonding.
- Participant had to be willing to return for follow-up examinations.

Each of the 40 participants received a cantilever RBFDP (CRBFDP) constructed from either a nonprecious alloy (Wirocast Co-Cr alloy, Bego) ceramic (VM 13, VITA Zahnfabrik) (MC group; n = 20) or a glass-infiltrated alumina ceramic (In-Ceram, VITA Zahnfabrik) (AC group; n = 20).

Clinical Procedures

Before starting the restorative treatment phase, each participant received dental hygiene instructions and treatment. In case of a missing central incisor, the abutment tooth was the contralateral central incisor, and when a lateral incisor was missing, the adjacent central incisor acted as the abutment. Abutment teeth were prepared minimally on the lingual aspect with a supragingival finish line and a shallow groove (2-mm length, 1-mm width, 0.5-mm depth).15 A full-arch impression was then made with polyvinyl siloxane (PRESIDENT, Coltène/Whaledent), and the interocclusal registrations were recorded.

The frameworks in the MC group were constructed from a base metal alloy (Wirocast) using the lost-wax casting technique. The wax pattern for the frameworks was invested and cast following the manufacturer’s instructions. In the AC group, the frameworks were fabricated from glass-infiltrated alumina (In-Ceram) using a slip casting technique following the manufacturer’s instructions.

After fabrication, the frameworks were tried in in the patient’s mouth, and the frameworks were renewed for any defect related to the restoration margin or occlusion that could not be corrected by simple adjustments. The retainer wings had an overall thickness of approximately 0.5 mm. All reconstructions in both groups were buccally veneered with either VM 13 in the case of group MC or with VM 7 (VITA Zahnfabrik) feldspathic ceramics in group AC, following the manufacturer’s instructions.

After try-in of the finished restorations, the fitting surfaces of the retainers were air abraded with 50-μm Al₂O₃ particles (pressure: 2.5 bar; duration: 10 seconds) followed by ultrasonic cleaning in 96% alcohol for 1 minute. After isolation of the prepared teeth with a rubber dam (OptraDam, Ivoclar Vivadent), the teeth were initially cleaned with a rubber cup and a fluoride-free polishing paste, rinsed, and dried. Then, the prepared enamel surface of the abutment tooth was etched with phosphoric acid (K-Etchant Gel, Kuraray) for 10 seconds, rinsed, and dried.

The CRBFDPs were bonded to the abutment tooth using chemically polymerized adhesive resin cement (PANAVIA 21, Kuraray) following the manufacturer’s instructions, and the excess resin was removed with sponge pellets. In order to promote the resin cement chemical polymerization process, an air-blocking gel (Oxyguard II, Kuraray) was applied (7 minutes). Careful evaluation of occlusion was performed, and an intraoral ceramic finishing kit (Edenta) was used when occlusal adjustments were indicated.

Clinical Evaluation

One week following the final cementation, the participants were recalled for clinical examination. After baseline recordings, two independent calibrated examiners (M.G. and W.A.) who did not take part in the procedures recorded the results consecutively during the same appointment. In case of discrepancies in
restorations considering the two types of failure that occurred (debonding for clinical retention and fracture for survival rates). \( P \) values less than .05 were considered to be statistically significant in all tests.

**RESULTS**

Forty participants (22 women, 18 men, mean age: 36.1 years) with 40 CRBFDPs were evaluated. The mean observation period was 106.7 ± 24.4 months (ranging between 6 and 125 months). The distribution of cantilever RBFDPs is presented in Table 2.

Altogether, three fractures were observed in the AC group at 6, 12, and 84 months. No significant difference was observed between the survival rates of MC and AC RBFDPs (MC: 100%; AC: 85%) (\( P = .075 \) (Kaplan-Meier, confidence interval [CI] = 92.8%)) (Fig 1).

Debonding was observed in the MC group and was seen in one participant, while with the AC group, debonding was recorded in six participants during the observation period. Debonded restorations showed mixed failures between the fitting surface of the restoration and the enamel. The allocation of debonding among study groups is presented in Table 3. Debonded reconstructions were recemented and continued in function during the follow-up period. Taking into consideration debonding as a complication, the overall clinical retention rate of cantilever RBFDPs was 82.5%.

### Table 1

**United States Public Health Service Clinical Criteria for Clinical Assessment of Cantilever Resin-Bonded Fixed Dental Prostheses**

<table>
<thead>
<tr>
<th>Clinical characteristics</th>
<th>Alpha</th>
<th>Bravo</th>
<th>Charlie</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marginal adaptation</td>
<td>No cement joint</td>
<td>Cement joint &gt; 50 ( \mu m ) without degradation</td>
<td>Cement joint &gt; 50 ( \mu m ) with degradation</td>
</tr>
<tr>
<td>Quality of reconstruction/tooth interface</td>
<td>Probe did not catch</td>
<td>Probe did catch, no gap, exposed enamel is polishable</td>
<td>Probe did catch, with gap, exposed cement is not polishable</td>
</tr>
<tr>
<td>Marginal discoloration</td>
<td>No marginal discoloration</td>
<td>Slight discoloration visible, but polishable</td>
<td>Distinct discoloration visible, not polishable</td>
</tr>
<tr>
<td>Chipping of ceramic</td>
<td>No chipping</td>
<td>Chipping, but polishing possible</td>
<td>Chipping, no polishing possible</td>
</tr>
<tr>
<td>Fracture</td>
<td>No fracture of the restoration</td>
<td>Fracture</td>
<td></td>
</tr>
<tr>
<td>Configuration of the contour</td>
<td>Correct contour, tight proximal contacts</td>
<td>Slightly under- or overcontoured, weak proximal contacts</td>
<td>Distinctly under- or overcontoured, no proximal contacts</td>
</tr>
<tr>
<td>Surface texture</td>
<td>Smooth, glazed, or glossy surface</td>
<td>Slightly rough, dull surface, polishable</td>
<td>Deep pores, rough, unevenly distributed pits, not polishable</td>
</tr>
<tr>
<td>Occlusion</td>
<td>Perfect occlusion and articulation</td>
<td>Minimal deviation in occlusion and articulation, correction achieved by grinding</td>
<td>Distinct deviation in occlusion and articulation, transversal and sagittal slide &gt; 1 mm</td>
</tr>
<tr>
<td>Occlusal wear</td>
<td>No wear facets on restoration or opposing teeth</td>
<td>Small wear facets (diameter &lt; 2 mm) on restoration and/or opposing teeth</td>
<td>Large wear facets (diameter &gt; 2 mm) on restoration and/or opposing teeth</td>
</tr>
<tr>
<td>Color</td>
<td>A perfect color match</td>
<td>Minimal mismatch in shade</td>
<td>A distinct shade difference</td>
</tr>
<tr>
<td>Assessment of tooth vitality</td>
<td>Distinct positive feedback on tooth vitality or negative feedback with endodontically treated teeth</td>
<td>Delayed reaction</td>
<td>Negative feedback but not with endodontically treated teeth</td>
</tr>
</tbody>
</table>

### Table 2

**Distribution and Location of the Cantilever Resin-Bonded Fixed Dental Prosthesis**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Metal-ceramic</th>
<th>All-ceramic</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Men</td>
<td>7 (35)</td>
<td>11 (55)</td>
</tr>
<tr>
<td>Women</td>
<td>13 (65)</td>
<td>9 (45)</td>
</tr>
<tr>
<td>Mean age (y)</td>
<td>34.4</td>
<td>37.8</td>
</tr>
<tr>
<td>Pontic location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central</td>
<td>13 (65)</td>
<td>14 (70)</td>
</tr>
<tr>
<td>Lateral</td>
<td>7 (35)</td>
<td>6 (30)</td>
</tr>
</tbody>
</table>

Data are reported as n (%) unless otherwise indicated.
Saker et al
Volume 33, Number 3, 2020

Three fractures were recorded for the AC group, which indicates that failures could not be eliminated even with the use of a cantilever design. However, no fracture was recorded with the MC reconstructions. Varied survival rates of CRBFDPS have been recorded in the literature, indicating that the clinical longevity of this type of prosthesis is affected by many clinical and technical factors. A study conducted by Briggs et al9 reported the mean service life of 54 metal-ceramic CRBFDPs was 27 months with an 80% clinical retention rate. In a more extensive investigation, Hussey and Linden22 observed 142 CRBFPDs over a period of 36 months and recorded an 88% retention rate, with 96% of the prostheses remaining functional. Additionally, Sailer et al reported a 100% survival rate of all-ceramic CRBFDPS after 6 years of clinical observation.21 In comparison, a 10-year study on anterior ceramic CRBFDPs reported a clinical longevity of 94%.24

Debonding of RBFDPs is considered the most common complication that could affect the success rate after 10 years of clinical observation. The clinical retention rate was 95.0% for the MC group and 70% for the AC group, which is considered statistically significant among the study groups (P = .02, log rank test) (Fig 2).

Abutment teeth showed no signs of endodontic complications, caries, or tooth fracture during the overall observation period.

**DISCUSSION**

In this retrospective study, a statistically significant difference was observed between the clinical retention rates of AC and MC CRBFDPs, so the first part of the null hypothesis was rejected. Since no significant difference was recorded in the survival rates of AC and MC CRBFDPs, the second part of the null hypothesis could be accepted.

In terms of clinical survival, no significant difference was observed between the MC and AC groups, which could be attributed to the low number of patients treated. Three fractures were recorded for the AC group, which indicates that failures could not be eliminated even with the use of a cantilever design. However, no fracture was recorded with the MC reconstructions.

Varied survival rates of CRBFDPS have been recorded in the literature, indicating that the clinical longevity of this type of prosthesis is affected by many clinical and technical factors. A study conducted by Briggs et al9 reported the mean service life of 54 metal-ceramic CRBFDPs was 27 months with an 80% clinical retention rate. In a more extensive investigation, Hussey and Linden22 observed 142 CRBFPDs over a period of 36 months and recorded an 88% retention rate, with 96% of the prostheses remaining functional. Additionally, Sailer et al reported a 100% survival rate of all-ceramic CRBFDPS after 6 years of clinical observation.21 In comparison, a 10-year study on anterior ceramic CRBFDPs reported a clinical longevity of 94%.24

Debonding of RBFDPs is considered the most common complication that could affect the success rate

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**Table 3** Debonded Cantilever Restorations (n) Over 10 Years of Clinical Observation

<table>
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</thead>
<tbody>
<tr>
<td>Metal-ceramic</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.02</td>
</tr>
<tr>
<td>All-ceramic</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
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of the prosthesis. In the present study, anterior MC CRBFDPs presented a highly successful clinical outcome after 10 years of clinical service, which could be attributed to the use of Co-Cr alloy for the fabrication of the MC framework due to the cost concern. Even in thin sections, the Co-Cr alloy is characterized by a high modulus of elasticity, and the higher metal affinity to oxygen for forming oxides on the metal surface might have favored the bonding process with resin cement.\textsuperscript{23} However, debonding was experienced in the AC group during the follow-up period. It was reported that airborne-particle abrasion of glass-infiltrated ceramics resulted in a remarkable percentage of adhesive failures that could be explained by inadequate microroughness to improve the adhesion between the prosthesis’ internal surface and the resin cement.\textsuperscript{24}

Future randomized controlled clinical trials with a larger sample size are recommended to confirm the results of the present study. Additionally, the use of InCeram alumina for framework fabrication is considered a limitation of this study. Moreover, one surface treatment was used for the intaglio surface of the prostheses, but another surface treatment seems to be more efficient in bonding improvement.

CONCLUSIONS

Although the glass-infiltrated AC anterior CRBFDPs exhibited a lower clinical retention rate compared to the MC CRBFDPs, the debonded prostheses were recremented and continued in function during the observation period. Additionally, an acceptable 10-year clinical endurance was recorded.

ACKNOWLEDGMENTS

The authors report no conflicts of interest.

REFERENCES