Patients provided with 24 ball attachment-retained removable partial dentures were followed up to 23.5 years. The prosthetic treatment included fixed partial dentures in 8 arches, and combinations of crowns and splint bars in 16 arches. All ball attachment matrices were supplied with vertical occlusal stops in contact with the patrices. A nonresilient hinged coupling was established between fixed partial dentures and removable partial dentures. Seventeen arches had only two or three remaining teeth. A total of 66 abutments for fixed partial dentures were included, 30 of which were root canal treated and supplied with posts. No technical failures (loss of retention/cement failure, root or tooth fracture, metal framework fracture) with the fixed partial dentures were recorded. With the removable partial dentures, additional retention with clasps was introduced in 2 of the dentures (in addition to 8 originally), 2 had to be remade after fractures, and 4 dentures were relined. Int J Prosthodont 1995;8:21-28.

Combinations of fixed and removable partial dentures are used in many different ways. Crowns, and fixed partial dentures (FPDs) which restore parts of the remaining natural dentition or are used as abutments for clasp-retained removable partial dentures (RPDs) are usually not included in the treatment alternatives that are known as fixed/removable partial dentures. The term generally refers to the use of attachments, double crowns, bars, etc. Overdentures with root attachments are sometimes included in the terms attachment-retained or precision attachment-retained dentures. The double conical crown is also a technical alternative combining fixed and removable prostheses. In some of the rather few studies that have been published regarding precision attachment-retained dentures, different types of attachments have been grouped in the same report.

A distinction between rigid and resilient combinations is made by Rantanen et al., who recommended that resilient connections should be avoided, as they showed a higher failure rate than rigid designs. Any clinical long-term studies of hinged or stress-distributing combinations are not available.

The conical crown/double crown prostheses have a rigid connection between the fixed and removable segments, and good results have been demonstrated. Öwall studied FPD/RPD combinations having only a rigid slide attachment; he reported good results with the RPD but failures, including tooth fractures, cement failures, and framework fractures, with the FPDs. That study could not determine if the rigid connection of the distal-extension RPDs increased the risk of technical failure. All types of fixed prosthodontics for compromised dentitions are at risk of technical failure. When comparing the results of those studies, the addition of an RPD has apparently not increased the risk of failure. There is, therefore, reason to study prosthetic designs using hinged connections of the removable to fixed segment.
Table 1  Dental and Denture Status of the Arches Opposing Those Treated with Ball Attachment-retained RPDs (n = 24)

<table>
<thead>
<tr>
<th>Opposing Arch</th>
<th>Maxillae</th>
<th>Mandible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural dentition only</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>RPD</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Complete denture</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Ball attachment RPD</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 2  Types of Fixed Components, and Number and Endodontic Status of Abutments

<table>
<thead>
<tr>
<th>Restoration Type</th>
<th>Number of Restorations</th>
<th>Number of Abutments</th>
<th>Number of Endodontic Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unilateral</td>
<td>3</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Anterior</td>
<td>5</td>
<td>27</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>39</td>
<td>15</td>
</tr>
</tbody>
</table>

especially in regard to prognosis, failure rate, and patient satisfaction.

The purpose of this investigation was to examine a group of patients treated with one type of nonresilient, hinged attachments—ball attachments—for the connection between FPD and RPD fabricated by one prosthodontist.

**Materials and Methods**

The material consisted of 24 FPDs with ball attachments in 21 patients. Three patients had such constructions in the maxillae, 15 in the mandible, and 3 in both arches. Twenty-one of the restorations included 2 ball attachments, and 3 included 1 attachment each. Thus, 6 maxillary and 18 mandibular prostheses were included. These patients represented all of those treated by the author over a period of 30 years (1964 to 1993) using nonresilient ball attachment constructions.

**Patients**

For the 21 patients (10 women, 11 men) aged 24 to 84 years (median 66 years) at the time of the initial treatment each arch was considered individually (n = 24).

Two patients, one with maxillary and mandibular restorations, and one with a mandibular restoration only, were undergoing psychiatric treatment, in part related to their denture problems. The tooth loss and the position of the remaining teeth, which was the indication for the initial treatment, did not permit treatment with a fixed partial denture only and the amount of remaining tooth precluded direct restoration and required crown restorations to permit service as an RPD abutment.

**Arches Treated**

The number, placement, and strength of the remaining dentition and its marginal bone support were not considered adequate to withstand the load from a rigid slide precision-attachment RPD. Therefore, a hinged connection between the fixed and the removable prostheses was chosen to provide some stress distribution.

The reasons for the tooth loss in the arches treated using the ball attachment constructions were: trauma (3 arches; 2 maxillary, 1 mandibular, patient ages 76, 31, 24 years); caries (5 arches; patient ages 57 to 74 years, mean 67.6); periodontal disease (6 arches; patient ages 43 to 66 years, mean 58.5); and a combination of caries and periodontal disease (6 arches; patient ages 60 to 84 years, mean 72.7). Caries as used in this context refers to large lesions, teeth with many restorations, root fillings, dowel posts and/or tooth or root fractures following very extensive conservative treatment, and periapical pathosis as a result of caries or previous restoration. In 4 of the arches (patient ages 64 to 77 years, mean 71.0), the original reason for the tooth loss could not be established.

**Opposing Arches**

The arch opposing the arch receiving the prosthesis was always treated completely during the same period. All patients except one maintained the same status in the opposite arch over the study period. This one patient was fitted with a ball attachment-retained RPD in the maxillae opposing a naturally dentate mandible. After 10 years, a ball attachment-retained mandibular RPD was placed following extractions necessitated by periodontal disease. This was recorded as two ball attachment-retained RPDs. The status of the opposing arches is presented in Table 1.

**Abutment Teeth and FPD**

The distribution of abutments in the arches treated and the types of fixed components are presented in Table 2.
Three arches had two splinted crowns unilaterally; two of these arches were treated following trauma and the other following loss of teeth from periodontal disease. One of the prosthesis was a unilateral maxillary obturator following a shotgun accident, and the ball attachment was supplied with a locking device.

Of the other restorations, five were conventional fixed partial dentures with pontics or splints (there were 6 unit FPDs, one was a 5-unit FPD, and one was a 4-unit FPD), and 16 incorporated an anterior bar connecting and splinting the abutment teeth. The bars that spanned an edentulous space of 4 incisors in 12 restorations (3 maxillary and 9 mandibular) and 3 incisors in 4 prostheses (1 maxillary and 3 mandibular) were also used for indirect retention of the RPDs.

Edentulous Areas

Twenty of the RPDs were bilateral distal extension (3 maxillary and 17 mandibular), 2 were maxillary unilateral distal extensions, one was an obturator, and 2 were large, anterior replacements.

Marginal Bone Support

The marginal bone support of the abutment teeth of the fixed partial dentures, as indicated on intra-oral radiographs when treatment was initiated, was 80% to 90% in 4 arches; 60% to 70% in 9 arches; 40% to 50% in 10 arches; and 30% in 1 arch. The tooth surface with the most reduced marginal bone support was used to characterize the arch, as most arches included very few abutment teeth and all were essential for the survival of the FPDs.

Ball Attachments

Gold Roach-type solid ball attachments measuring 2.5 mm in diameter with patrices (Sjodings AB, Solna, Sweden) or 2.5 mm diameter patrices with an activation slot in the ball (Cendres & Metaux SA, Biel, Switzerland) were used. The respective lengths of the matrices were 4.0 and 4.8 mm.

In all the restorations, the matrices were supplied with a gold vertical occlusal stop and were nonresilient, i.e., the balls were in contact with the vertical stops when the relationship between the fixed and removable partial denture was established (Fig 1).

Prosthodontic Technique

The fixed prostheses were made according to generally accepted principles for retention, occlusion, and vertical dimension. The bars were made either of prefabricated, round metal bars (n = 4), curved to fit the residual ridge and provide sufficient gingival relief at the proximal surface of the abutment teeth and soldered to the crowns, or of individually shaped (n = 12), cast metal connectors (Fig 2).

All removable partial dentures had cobalt-chromium frameworks (Vitalium, Austenal, Chicago, IL). In the maxillae, all major connectors were metal palatal plates. In the mandible, 16 were cingulum bar connectors resting on the FPD and not covering gingival tissue, and 2 were lingual bars, owing to space problems, as the FPDs had short clinical crowns.

Distal extension bases were extended to include either the retromolar pad or the tuberosity. All artificial teeth in the RPDs were of acrylic resin.

The patress attachment of the balls was mounted.
in the incisal/coronal part of the crowns to preserve the matrices' length and to provide adequate gingival relief on the attachment side of the crowns (Figs 3a and 3b).

All three of the 2-crown splints were supplied with auxiliary clasping (for the obturator patient in the form of a locking device) at the time of initial placement. Of the 5 conventional FPDs, 2 were initially supplied with clasps, and of the 16 FPD bar constructions, 3 were initially supplied with clasps and one with Ipsoclip (Cendres & Métaux SA) onto the bar. No other retention to the bars was used.

Recall and Observation Period

The patients were followed by individual recall, usually at 6-month intervals. Some patients did not respond to the recalls and were then recorded at the time they returned. Three patients consulted other dentists in the area where they lived, from whom professional information could be obtained for this study. Patients who died, and one patient who moved from the district and with whom contact was lost, were recorded for that part of the observation period in which they could be evaluated.

The observation period was calculated in months from the day of insertion of the prosthesis up to the last clinical evaluation. For patients who lost their restorations as a result of extraction, obtained alternative treatment, or abandoned their RPDs, the observation period terminated. All other patients were followed continuously and complications, if any, were recorded.

Results

Observation Period

The observation period ranged from 14 to 282 months (median 89). For 9 prostheses, the observation period was terminated because the patient died or moved from the district. One patient was followed for 90 months, after which contact was lost. Four prostheses were lost, 3 as a result of extraction of the abutment teeth necessitated by periodontal disease, and 1 because the patient abandoned her mandibular RPD and did not get it adjusted for re-use (see section below on patient satisfaction).

Two RPDs in one patient had to be abandoned and the bar constructions altered for fixed partial dentures after 8 months (see section below on patient satisfaction). Eight prostheses, including two that were observed by other dentists, are still under observation (see Table 2). The distribution of the treatments over the 30-year period is: first 10 years—10, second 10 years—8, and last 10 years—6.

Patient Satisfaction

All removable prostheses included anterior teeth, obligating their use for social/esthetic reasons. Nine patients had complete dentures in the opposing arch; the others had their natural dentition, with no removable denture (5 patients) or with a removable partial denture (7 patients). All but one, however, found the prosthesis satisfactory and well functioning. This patient had also had severe denture problems before and was under psychiatric care at the time of prosthodontic treatment. Maxillary and mandibular ball attachment-retained RPDs were tried for 8 months. However, the patient could not tolerate the removable dentures and, in spite of a very reduced number of abutments, superstructures were fabricated to modify the bar constructions to fixed partial dentures. The observation period for this patient was therefore terminated.

One other patient was also undergoing psychiatric care for denture problems at the time of prosth-
thetic treatment. He had a complete maxillary denture and an overdenture in the mandible retained by root attachments on endodontically treated canines. He was provided with crowns on the canines and a connecting bar, two ball attachments and an RPD. This was used for 117 months until the canines were lost as a result of periodontal disease.

One patient, 81 years old at the time of initial treatment, was provided with crowns on two mandibular canines and one lateral incisor, a connecting bar, two ball attachments, and an RPD. She used this RPD satisfactorily for 42 months, over which time she became severely senile and stopped using her RPD. The observation period was then terminated.

None of the patients experienced any problems in manipulating their RPDs when placing or removing them.

Retention and Stability

All patients were asked about retention at the follow-up visits. Two patients received auxiliary claspings after 69 and 164 months, respectively, as they considered the retention unsatisfactory. Others were satisfied.

The slots in the balls were never used for activation. This was avoided to prevent fracture, which could not be repaired since the balls were soldered to the FPDs.

The RPDs without any auxiliary claspings had almost no active retention in the path of RPD placement/removal, but they had excellent stability against horizontal displacement. This might account for the patients’ adaptation and satisfaction.

Technical Maintenance

Relines. Four mandibular RPDs were relined because of tilting around the hinges/ball attachments after 40, 41, 74, and 90 months. At the same time, the artificial teeth were repositioned or occlusally corrected. Re-establishment of the RPD-mucosa relationship was also undertaken at remakes.

Restorative Procedures. Seven crown margins required restoration as a result of caries. One blind patient received five restorations over the last 6 years of her 18-year observation period, but retained her prostheses until her death at the age of 81. Sixty-six abutment teeth in all were included in the FPDs examined, and the mean observation period of 7.5 years indicates that caries control had been achieved.

In three RPDs, the acrylic artificial tooth housing the matrix fractured, and in one RPD all the acrylic teeth had to be replaced as a result of wear (after 99 months).

Remake and Major Corrections of RPD. After repairs of two mandibular cobalt chromium frameworks had failed, they were remade to fit the original fixed partial dentures.

One patient was provided with a duplicate maxillary denture for social reasons; it was used instead of the intact original prosthesis.

In two mandibular restorations, the canines became completely periodontally compromised after 30 and 42 months, respectively. The amount of marginal bone support on these two teeth was very reduced at the time treatment began, as a result of gingival stripping caused by the previous RPDs. One of these patients rejected treatment. The other had the bar shortened to a mesial arm extending from the remaining tooth, and the compromised tooth was extracted. The RPD was adjusted. After a further 11 months, the retained abutment tooth also required extraction, a complete denture was placed, and the observation period terminated.

No technical failures, including loss of retention/cement failure, root or tooth fractures, or metal framework fracture, occurred with the FPDs.

Prognosis

The patient who was unable to accept her 2 RPDs had no technical failures during the 8 months that they were in use. She was accordingly excluded from the material in presenting the technical prognosis. Of the remaining 22 restorations, 3 failed because of periodontal complications (after 43, 54, and 117 months). One of these had had one of the two abutments extracted earlier and the denture was altered, and one had had a remake of a fractured RPD. One further RPD framework fracture occurred and the denture was remade. The prognosis is summarized in Fig 4 and some examples are shown in Figs 5 to 7.

The patient who was offered a shortening of the FPD and an adjustment of the RPD is reported as a partial failure.

Minor repairs, relines, replacement of loosened or worn resin teeth, restorations, and auxiliary claspings did not affect the prognosis to any notable extent; consequently, they are reported under technical maintenance.

Discussion

There are several indications for the use of attachments as a coupling between an FPD and an RPD. Esthetics, meaning the avoidance of clasps, is
This study reports the results of one type of precision attachment–retained RPDs used on a selected group of patients treated by one prosthodontist. The results are thus far from applicable to other groups of patients treated by other dentists. As there are very few existing reports about precision attachment–retained RPD, and especially ball attachments, there is clearly a need to collect experiences and results. One advantage of this material is that the same author has reported a material of distal extension removable partial dentures retained by rigid intracoronal slide attachments from the same period of time. Comparisons of the two attachment models are thus possible without the disadvantage of different clinicians being involved.

It must be noted that (1) the patient material includes a majority of elderly patients with compromised dentitions, (2) the marginal bone support of several of the teeth included in the FPDs was reduced, (3) many abutment teeth were endodontically treated and posts were placed, and (4) two patients were problem patients to such an extent that they were under psychiatric care. These facts must be considered when comparisons are made. Although about 50% of the patients had a history of caries or cavities at the time of prosthetic treatment, caries was well under control. Only three patients developed carious lesions in connection with the FPDs, two of whom had only one carious lesion each.

The overall technical results of the treatment with ball attachment–retained RPDs seem very good. At 15 years the success rate was 60%, and at 10 years it was 70%—if patients who died or moved are distributed in failed and satisfactory groups in relation to frequencies. This is much higher than the results presented by Vermeulen, who found that the 50% survival time was 8 years for a material of 183 precision attachment–retained RPDs, including 40% ball attachments.

The material of rigid slide attachments presented by Öwall had an extrapolated 50% survival time of about 20 years, and a survival rate of about 65% up to 15 years. These figures are almost exactly the same as those for this material.

When compared to the material of rigid slide attachments reported by Öwall, there also seems to be a similar frequency of technical failures. The need for relinings differed: 9.5% (two postextraction relines excluded) for the rigid slide material and 16.6% for the ball attachment material.

It is noteworthy, however, that in this material there were 18 mandibular (75%) and 6 maxillary restorations. In the rigid slide attachment material, the corresponding figures were 14 mandibular (26%) and 39 maxillary prostheses.
A comparison of mandibular prostheses only reveals that, even though those retained with ball attachments had fewer abutments and a much higher frequency of root canal–treated abutments with root posts, there were fewer failures. It must be emphasized, however, that this comparison was made only for the mandible, where the FPDs in almost all the patients were in normal incisor relation, ie, there was a horizontal overlap counteacting the risk of a frontal tilting of the FPD.

It is also noteworthy that the Roach ball attachment was the first type of attachment to be fabricated, and that it is still being produced and used. 14,16

The results of Hultén et al, 1 who studied a conical crown/double crown–retained RPD material, indicate a high risk of failure. The failure rate in their material was considerably higher than in the present material when using ball attachments, even though the quality and distribution of the abutments for the crowns were similar in both studies. Conical inner crowns are separate and the splitting is obtained by the RPD. This method does not give the same reliable and stable splitting as that provided by bars used in conjunction with the ball attachments as bar–splinted FPDs with nonresilient extracoronal ball attachments.

Thus, it is essential to point out that the material presented herein includes only nonresilient extracoronal ball attachments on splinted abutments.

Fig 6 Pretreatment (a) and follow-up (b) radiographs 70 months later. The patient had his FPD and RPD until his death, 96 months after treatment. A complete maxillary denture was opposing.

Fig 7 Patient with the technically weakest abutment teeth: two mandibular canines with root anchors on posts to support an overdenture. The patient could not tolerate the overdenture. The construction above functioned for 117 months, when it was lost because of periodontal complications and tooth mobility. A complete maxillary denture was opposing.

Conclusion

In this material of 24 RPDs coupled to FPDs with nonresilient Roach ball attachments, followed for periods ranging from 7 to 282 months, few technical failures were recorded. Two RPD frameworks were remade after fractures, 4 required relining, and 2 (in addition to an initial 8) required auxiliary clasping. No technical failures occurred with the FPDs.
References