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# Removable Prosthodontics for the Management of Severe Toothwear

**Abstract:** Toothwear is becoming increasingly more common for dentists to manage as the population is maintaining its teeth for longer. A large proportion of cases can be managed by means of adhesive dentistry in conjunction with preventive advice. There are, however, patients with severe toothwear alone, or toothwear in conjunction with missing teeth, which would be best served with a removable prosthodontic approach. This is particularly the case where dental implants are not indicated or appropriate. This article illustrates the use of removable prosthodontics for the management of toothwear and highlights the importance of these restorations in certain cases. It also considers the supportive programme required to ensure success of this treatment modality.

**CPD/Clinical Relevance:** Toothwear is a prevalent dental problem that cannot always be addressed with an adhesive restorative or fixed prosthodontic approach, particularly when the toothwear is severe and or in combination with existing missing teeth.

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Toothwear, also known as non-carious tooth surface loss, is defined as the loss of dental hard tissue by mechanisms other than caries or trauma. Toothwear can be caused by many processes but typically has a multifactorial aetiology, usually as a combination of erosion, attrition and abrasion.<sup>1-5</sup> Although some toothwear is normal or physiological due to natural ageing, severe toothwear at a higher rate than normal can produce symptoms and even masticatory, functional or aesthetic

concerns. In partially dentate patients with severe toothwear, successful management can be challenging.

## Prevalence

Toothwear is a dental condition of increasing concern in the UK population, as demonstrated by the findings of the 2009 Adult Dental Health Survey. Seventy-six percent of dentate adults in 2009 showed signs of wear, compared to 66% in the 1998 survey.<sup>1</sup> Of those dentate adults, 15% experienced moderate wear, exposing large areas of dentine and 2% displayed severe wear, which exposed the pulp or secondary dentine. Men (70%) were affected by toothwear more than women (61%) and even some adults in the younger age group (16–24 years) showed signs of moderate wear (4%). As the younger generation retain more of their teeth into old age, early identification and management of their disease will be essential in order to prevent increased numbers of adults with excessive wear.

## Patient presenting issues

There are numerous reasons why patients who have experienced severe toothwear seek dental treatment, with the most common including aesthetic concerns, functional problems and concern about further wear. From a clinical standpoint, toothwear is treated for very much the same reasons; the prevention of further destruction, re-establishment of the occlusal vertical dimension (OVD) and restoration of the remaining dentition for function and aesthetics. Deciding on the best treatment option for patients with severe toothwear is difficult, with a recent systematic review concluding that there is currently no evidence of which treatment option is best.<sup>6</sup> When patients have multiple missing teeth or multiple severely worn teeth, the provision of a removable prosthesis can be a predictable way to restore aesthetics, function and the OVD. This can, in severe cases, be simpler and more predictable than using conventional crown and bridgework, dental implants, adhesive restorative techniques and crown lengthening surgery.

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**Figure 1.** An example of a case where the option is to overdenture the roots rather than extracting them.



**Figure 2.** Teeth worn sufficiently that reducing them to gingival level would be appropriate.

### Treatment planning decisions related to the degree of remaining tooth tissue

A key component to the treatment planning phase is identifying the aetiological cause(s) of the toothwear, followed by appropriate interceptive and preventive management. Good quality impressions need to be made so that suitably articulated models, in centric relation, can be constructed to ensure the principles of denture design are followed. A difficult decision faced by clinicians is when to restore a tooth with a fixed restoration or when to cover/onlay/overlay a tooth with part of a removable prosthesis. Unfortunately, there is relatively little in the way of high quality evidence available to be able to answer this dilemma definitively.<sup>6</sup>

Within the literature, minimal preparation heights of 3 mm for anterior teeth and premolars<sup>7,8</sup> and 4 mm for molars<sup>9</sup> have been recommended for conventional crown restorations. However, in severe wear cases with a planned increase in OVD, a short crown preparation in conjunction with an increased crown height would result in poor resistance form, poor retention form and a high risk of decementation; unless surgical crown lengthening was considered first. Unfortunately, there is no evidence suggesting the ideal preparation height for the provision of crowns in toothwear

cases, therefore the clinician needs to make a prudent decision as to whether a crown would be retentive on a case-by-case basis.

With regards to composite resin restorations, the presence of enamel is essential for a predictable bond. Patients with severe toothwear have a significantly lower surface area of enamel to bond to, resulting in composite build-ups which have a higher risk of failure. Additionally, composite resin restorations in toothwear patients with parafunctional habits are suspected to fare less well with regards to survival.<sup>10,11</sup>

Occlusion may also have an influence on the survival of anterior composite restorations, with Class II division 2 malocclusions and Class III malocclusions having significantly higher survival rates reported by Gulamali *et al.*<sup>11</sup> However, Redman *et al* had earlier reported that Class II division 2 cases performed less well.<sup>10</sup> As there is little evidence available with regards to the ideal amount of coronal tooth tissue necessary for successful composite restorations in toothwear patients, the decision lies with the instinct of the clinician.

### Removable prosthodontic treatment options for the worn dentition

In patients with severe toothwear resulting in very little supragingival tooth tissue, maintaining these teeth beneath a denture can still have several benefits which include preservation of alveolar bone, maintenance of the proprioceptive feedback and provision of retention and stability. Retention of tooth roots reduces the resorption of the alveolar processes, not only in the region of the roots but in edentulous regions also.<sup>12</sup> This is most significant in the mandible, whereby maintaining roots under an overdenture can preserve up to 8 times as much alveolar bone when compared with completely edentulous patients restored with conventional dentures.<sup>13</sup>

Retaining tooth roots maintains the proprioceptive feedback mechanism through preservation of the periodontal ligament and pulp. Studies have compared the function of overdentures to conventional complete dentures, and results have shown that overdenture

patients have improved occlusal forces,<sup>14,15</sup> masticatory efficiency<sup>14,16,17</sup> and awareness of mandibular position<sup>15</sup> as a result of maintaining the proprioceptive mechanism. Tooth roots can also act as a source of retention and stability for removable prostheses. Retention can be gained from tooth roots by frictional fit between the denture and the root abutment or by utilizing precision attachments. Similarly, tooth roots can aid stability of the prosthesis by resisting lateral forces. There are potential disadvantages and challenges that will be discussed later but these include the risk of loss of vitality, and development of caries and periodontal problems. There can also be difficulties achieving anterior aesthetics where there are prominent roots which may prevent a flange being used.

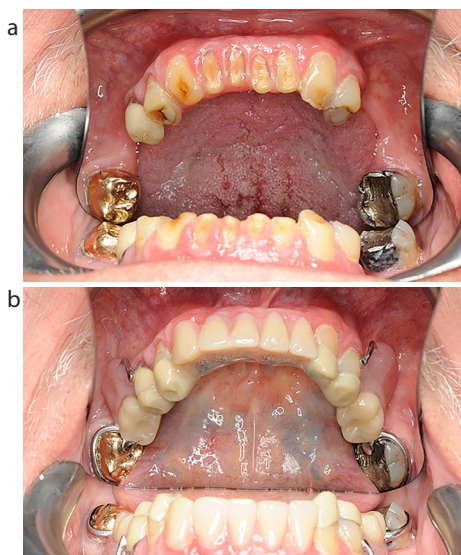
When presented with a partially dentate patient with severe toothwear, there are several treatment options to consider. If the worn teeth are beyond restoration or the patient cannot tolerate extended treatment (which may include the need to consider surgical crown lengthening to enable a fixed prosthodontic treatment option or multiple root fillings) extraction and replacement with conventional complete or partial dentures should be considered. The disadvantage of this irreversible treatment option is the potential for poor tolerance of a removable prosthesis. Figure 1 is an example of a case where the option of an overdenture of the roots would provide the benefits as mentioned above.

For teeth that are so severely worn that there is less than a third of remaining supragingival tooth tissue, a very simple option is the reduction of the residual clinical crown and provision of complete or partial overdentures. Figure 2 is an example where it would be appropriate to reduce the remaining clinical crown height of the maxillary incisors. As overdentures completely cover the natural teeth, aesthetics and occlusion can be controlled relatively easily. With regards to preparation of teeth already worn down to gingival level, usually only minor tooth preparation is necessary to smooth the root face. Occasionally, gold copings and precision attachments can be incorporated into the root surface.

An alternative to covering the

natural teeth completely with a prosthesis is partial restoration of the worn surfaces using complete/partial onlay or overlay dentures. Onlay partial dentures are a subset of overdentures and are described as removable partial dentures that have components restoring the entire occlusal/incisal surfaces of abutment teeth to restore them into a functional occlusion.<sup>18,19</sup> Onlay partial dentures can be considered where there is 1/3 to 1/2 of coronal tooth present and the remaining tooth tissue is healthy with acceptable aesthetics. Onlay dentures can be beneficial in circumstances where further reduction of the abutment tooth for the provision of a conventional overdenture could lead to endodontic complications, and when fixed restorations are contra-indicated (eg patients' desires, financial considerations, inability to tolerate treatment). When considering any form of onlay denture where there remains only a third to a half of the remaining tooth, it is essential that the pattern of toothwear is carefully assessed. This type of denture relies on the remaining tooth for retention with clasps. Therefore, surveying of the primary cast(s) for appropriate undercuts is a fundamental component of the decision-making process. It can be difficult to identify appropriate undercuts within the tooth that is to be onlaid. Furthermore, a patient with attrition or suspicions of parafunctional activity may require careful occlusal planning to provide a stable, resilient and retentive overdenture. Figure 3 demonstrates a case where onlays anteriorly have produced an aesthetic result, and have used the posterior teeth not affected by toothwear for retention.

It is sometimes considered advantageous to provide onlay dentures as a transitional prosthesis, where major tooth preparation is initially avoided until patient adaptability to restorative treatment has been tested. Figure 4 shows the all acrylic transitional prosthesis first used for the case in Figure 3. A disadvantage of onlaying teeth is the formation of a horizontal line across the facial surfaces of the restored teeth. This is often tolerated well posteriorly; however, this should only be considered anteriorly for patients with a low lip line. Onlay components can be made from metal or acrylic. Metal is beneficial when only a thin layer of overlay is required (<2 mm) to restore the occlusion.



**Figure 3. (a, b)** An example of a case where a partial denture has been designed to overlay the remaining tooth surface to produce a good aesthetic result.



**Figure 4.** A transitional all acrylic denture overlaying the anterior teeth and onlaying the posterior teeth at an increased occlusal vertical dimension.

It may also be indicated in patients with a diagnosis of attrition where there is a history of wearing the occlusal surfaces of a previous acrylic onlay denture, or there are concerns of parafunctional activity that could lead to early fracture of a resin-based material (Figure 5). If onlays need to be aesthetic or >2 mm thick, acrylic resin is indicated usually in combination with a cobalt chrome substructure (Figure 6). Alternatively, composite onlays (but these can wear quickly also) which are often very aesthetic, can be incorporated with the baseplate. Tooth preparation for onlay abutments includes removal of any unsupported enamel and beveling of sharp angles at the occlusal junction or near



**Figure 5.** Overdenture with metal occlusal surface due to history of fracturing occlusal covering previously made in acrylic.



**Figure 6. (a, b)** An overdenture with metal sub-framework in cobalt chrome.

minor connectors.

Overlay dentures, another subset of overdentures, cover worn or damaged teeth with full labial veneer facing, as well as occlusal coverage (Figure 7). Overlay dentures do not have a flange so are less bulky, and are therefore advantageous in situations where a flange would compromise anterior aesthetics. Overlay dentures are indicated when there is 1/3 to 1/2 of coronal tooth present, the aesthetics of the abutment teeth are poor, when a flange is not possible and when reducing the remaining tooth tissue for



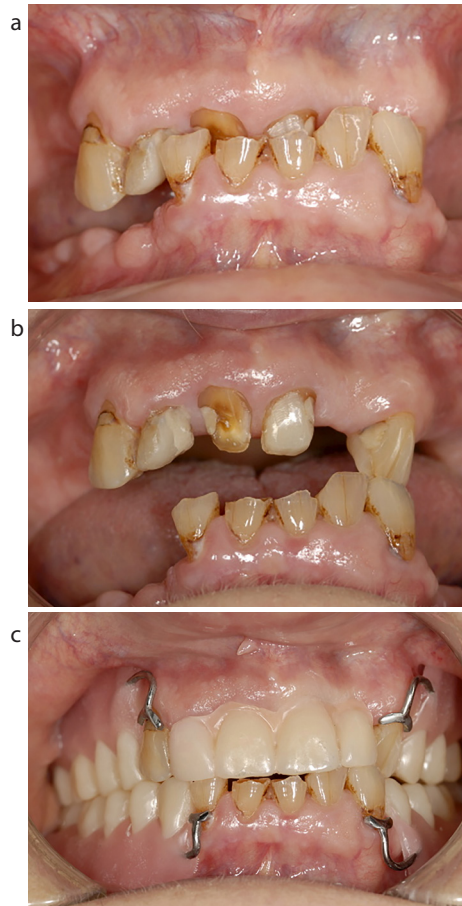
**Figure 7.** An example of an overlay denture.

complete coverage would lead to the need for endodontic treatment.

### Occlusal changes as a result of toothwear

For partially dentate patients with severe toothwear, restoration can be challenging due to the anatomical changes resulting from toothwear, the loss of occlusal contacts and changes in OVD.

Severe toothwear can lead to loss of the OVD as a result of loss of tooth tissue although, interestingly, not in the majority of patients. Loss of OVD can be detected clinically by reduced lower anterior face height, over-closed commissures, narrowed vermilion borders and a reduced display of teeth whilst smiling and during speech. Loss of OVD can have a horizontal as well as vertical component, with loss of anterior tooth tissue causing anterior mandibular positioning. Anterior mandibular positioning is thought to be a result of a forward rotation of the mandible, edge-to-edge tooth contact following loss of tooth height, habitual anterior posturing of the mandible as a result of loss of anterior guidance and dento-facial bone remodelling.<sup>20</sup> These cases are often straightforward to treat with removable prostheses, as inter-occlusal and freeway space is conserved throughout the toothwear process. However, many patients with toothwear become accustomed to over-closure and anterior mandibular positioning, and restoring them to their centric relation position and OVD can feel strange and uncomfortable for them. Therefore, a period of adaptation with a transitional prosthesis is essential.



**Figure 8. (a–c)** Demonstrate a patient who postures her mandible forward but in centric relation a stable tooth position can be used to construct overlay dentures at an appropriate OVD.

Occasionally, anterior mandibular positioning may occur as a result of mandibular deviation caused by natural tooth contacts. In some cases, only one or two natural tooth contacts in centric relation may be present, whereas multiple tooth contacts in an eccentric mandibular position are present on the worn dentition. In such cases, it is important to identify and record these tooth contacts in centric relation. Often in these cases, correcting the mandibular position to the centric relation as guided by natural tooth contacts can create the required inter-occlusal space to provide restoration. Figure 8 demonstrates a case of a patient who had never worn dentures but postured her jaw forward, and resulting in over closure (Figure 8a). By guiding her into a retruded arc of closure,

it was possible to identify a tooth-to-tooth contact (Figure 8b) and provide a position from which successful overlay and overdentures could be provided (Figure 8c).

Toothwear is often compensated for by alveolar compensation, which is continuous tooth eruption and alveolar bone growth following toothwear.<sup>21</sup> Toothwear without a loss in OVD indicates a level of dento-alveolar compensation has occurred, and is often more difficult to treat as the creation of interocclusal space is necessary. Furthermore, in partially dentate patients there may be areas of dento-alveolar compensation and areas of alveolar atrophy, making it more challenging to plan a new OVD. In wear cases where dento-alveolar compensation has occurred, increases in the OVD is driven by aesthetics, material properties and patient tolerance. Altering the OVD within the range of 2–6 mm has been shown to have no visually distinguishable effect on face height.<sup>22</sup> Fortunately, increasing the OVD in such cases is often very well tolerated, and a recent systematic review reported that a permanent increase in the OVD is a safe and predictable procedure.<sup>23</sup> Whenever the OVD is being increased, it is fundamental that a transitional prosthesis is used to assess patient tolerance.

### How to decide on a new OVD

Whether there has been a loss in OVD or not, increasing the OVD should be planned around aesthetics, functional stability and adequate freeway space. Clinically, the required increase in OVD can be estimated by measuring interocclusal distance (taking into account necessary freeway space), estimation of former crown height, necessary space for restorative materials, lip competence and phonetics. By taking impressions of the worn dentition, the planned increase in OVD can be prescribed to the laboratory based on the use of occlusal rims which may include onlay/overlay or overdenture of the worn teeth. It is paramount that the primary casts are surveyed to identify path of insertion and utilizable undercuts for retention of the prosthesis, if onlays are to be considered. In situations where teeth are so worn down and no undercut is present, complete coverage with an overdenture should be considered. The wax try appointment will

help determine whether the increase in OVD is appropriate and also allows the clinician and patient to assess aesthetics and phonetics. Where there are no natural tooth contacts in central occlusion, centric relation should be used to provide a reproducible occlusion.

### Transitional prostheses

For the restoration of severe toothwear patients, it is highly recommended to undergo a transitional phase of treatment by providing a transitional simple acrylic removable prosthesis incorporating the new OVD and reorganized occlusion. Providing a transitional prosthesis is a reversible, non-invasive and cost-effective method to assess the new OVD, patient tolerance to the new OVD, patient tolerance to a removable prosthesis, aesthetics, phonetics and denture design. Additionally, a transitional denture can be beneficial to prevent further wear, monitor teeth of uncertain prognosis, whilst providing a positive psychosocial impact for the patient. A recent systematic review investigating the best treatment options for toothwear patients recommended that testing an OVD increase with a removable prosthesis should be conducted before any definitive treatment is completed.<sup>6</sup>

The transitional prosthesis should aim to provide an occlusion with even contacts in centric relation. It is unwise in the transitional phase to undergo any considerable irreversible tooth reduction. However, minor tooth alterations may be necessary to remove undercuts, unsupported tooth tissue or sharp angles to allow an appropriate path of insertion. Therefore, onlay or overlay prostheses are commonly used as transitional prostheses prior to deciding whether to reduce worn teeth further or not. Transitional prostheses are used for a period of up to 6 months (depending on the adaptability of the patient), with regular review appointments in between for any necessary occlusal adjustments.

Once confident that the patient has adapted to the new OVD and occlusion, definitive alterations to the abutment teeth can be made whilst the patient continues wearing the transitional prosthesis. This may include composite build-ups, cast restorations, precision attachments and

definitive reduction of abutment teeth. The transitional prosthesis can be easily modified following any definitive tooth alterations to maintain the occlusion. Woodley *et al* demonstrated in their audit that provisional all acrylic dentures were prone to fracture and therefore should be replaced with the definitive prosthesis as soon as possible.<sup>24</sup>

### Definitive tooth modification

For any tooth planned as an overdenture abutment, the tooth should be rounded, smoothed and polished into a dome shape with no sharp angles or unsupported tooth tissue, with cervical margins beveled and located supra-gingivally. In instances where the tooth preparation is very irregular, gold copings are indicated, however, it must be recognized that secondary caries is difficult to detect beneath such restorations. Precision attachments may also be indicated in situations where direct retention is required and for root-treated teeth, cast post-retained copings or precision attachments can be considered. It is not within the scope of this article to describe precision attachments in detail, and further reading is available elsewhere.<sup>25,26</sup>

For all uncovered abutment teeth, similar tooth modification as required for conventional partial denture preparation is advised. This includes where necessary the removal of unfavourable tooth undercuts, preparation of guide planes to enhance stability and retention, and preparation of rest seats to allow more favourable loading of abutment teeth and avoidance of occlusal interferences. If the abutment teeth are heavily restored, crown restorations designed with occlusal rest seats, guide planes and appropriate undercuts for clasping should be considered.

### Definitive dentures

Following a successful period of adaptation with a transitional prosthesis and once definitive tooth preparation is complete, a definitive prosthesis can be constructed. The OVD can either be copied from the transitional denture using calipers or a Willis gauge, or increased at this stage if necessary. To copy the occlusal scheme of the transitional denture, an anterior

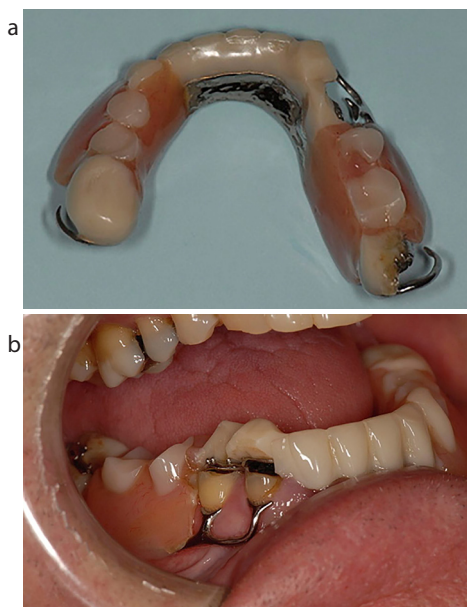
positioning jig can be utilized.<sup>27</sup>

The base of the definitive denture can be constructed from acrylic resin or metal alloy, such as cobalt-chrome. The benefit of using a metal substructure is the increased rigidity and resistance to dimensional alterations during processing, as compared to acrylic resin, the ability to use the material in thin section, the ability to use cast clasps/precision attachments and the ability to use rest seats on certain abutment teeth which provide improved load distribution (parallel to the tooth's long axis). Cobalt chrome can be cast using traditional techniques or constructed using CAD/CAM and direct laser metal sintering. It may be sensible if acrylic is chosen to request high impact resin to resist fracture, especially in suspected parafunction cases.

When choosing the material for onlay components, it is important to consider the interocclusal space. When interocclusal space is <2 mm, a metal alloy can be considered as they are strong and rigid in thin section. However, due to aesthetic reasons, metal onlays are often limited to the posterior dentition. When interocclusal space of >2 mm is present, acrylic resin onlays are indicated (usually with a metal substructure to support the resin). Prosthetic teeth can be made from acrylic resin, composite resin or porcelain. Acrylic resin has the benefit of being easily repaired, cost-effective and aesthetic, however, is prone to fracture in thin section and can wear at an increased rate in comparison to enamel. Composite resin is repairable and has an abrasion rate similar to enamel, however, it is brittle in thin section (eg veneers in overlay dentures). Porcelain has excellent aesthetics, however, it is brittle in thin section, abrasive to enamel and difficult to repair.

### Maintenance requirements for overdentures

It is important to identify and control the aetiological causes of toothwear in the management of cases with adhesive and conventional prosthodontic techniques for long-term success. The same is true of patients managed with removable prostheses. Further tooth surface loss will be detrimental to the fit and function of a removable prosthesis. Removable prostheses could also act as a holding



**Figure 9.** (a, b) Fracture of acrylic onlay surfaces on a denture that had been in service for 5 years.

reservoir for intrinsic and extrinsic acid and compound the issue of erosion.

In some patients, toothwear could be seen as a lifelong process and therefore it is important to recognize that, after providing a denture for a patient, wear or fracture could occur. Therefore, the design of the denture should allow for an appropriate thickness of material on onlay/overlay surfaces and that the retentive and supportive chrome framework will enable future repairs. This may require the worn teeth to be further reduced to provide sufficient space for the prosthesis, with enough bulk to resist fracture. Figure 9 shows fracture of the acrylic onlay surfaces of a denture after 5 years of function. Woodley *et al* reported that 47% of removable partial denture failures were due to fracture or wear of the incisal or occlusal surfaces in a study of 50 patients with severe toothwear.<sup>24</sup> Material choices are important for occlusal surfaces to ensure no detriment to the opposing natural dentition. Metal backings, for example, might be considered appropriate for a patient who presents with severe attrition to reduce the rate of wear of the acrylic teeth, or in a bruxist, to prevent fracture of the tooth facings overlaying the worn anterior teeth. This has the potential to cause wear of the opposing teeth, unless



**Figure 10.** Same case as in Figure 9 showing caries, endodontic access coverings and gingival inflammation in a patient who failed to attend a maintenance programme.

gold alloy is considered, and therefore knowledge of the aetiology is fundamental to this decision-making. It may be better to accept the need to replace worn denture teeth than risk wear of the opposing dentition.<sup>28</sup> Alternatively, a soft or hard nightguard may be considered to protect the opposing teeth. For posterior teeth, gold soldered on to the chrome framework or adhesively bonded to the acrylic teeth may be considered to prevent excessive wear of acrylic teeth, whilst limiting damage to the opposing teeth. The use of root face attachments to improve retention is also associated with higher prosthetic maintenance requirements.<sup>29,30</sup>

It is unusual for patients with toothwear to present with caries and periodontal problems. However, the introduction of a prosthesis can change the oral environment and therefore place the patient at risk of caries, periodontal disease and associated endodontic problems. It is therefore imperative that appropriate preventive advice is given to the patient and that patients are seen for regular maintenance reviews. Figure 10 illustrates the development of caries, marginal gingivitis and endodontic lesions in a patient who failed to attend his maintenance appointments having worn an overdenture for 5 years.

A number of longitudinal studies on overdenture populations have been published. Whilst the data needs some caution in its interpretation with regards to the management of toothwear patients treated with overdenture, onlay and overlay dentures, the importance of good oral hygiene and attendance at

recall would appear paramount. The rate of tooth loss reported, for these overdenture populations, is between 4–20% in studies of 5 years or more.<sup>31–36</sup> The majority are lost because of periodontal disease, caries and endodontic lesions. Endodontic issues were frequently associated with loss of restorations and secondary caries. In the study by Ettinger and Qian,<sup>37</sup> they found that 19.8% of abutments lost vitality but, after introducing the application of a three step bonding agent to vital root faces on a yearly basis, no further teeth lost vitality. It has also been identified that the rate of caries and periodontal disease is greater if the patient wears the denture all day and night versus daytime wear only.<sup>38,39</sup> Dependent on the cause of toothwear, removing the prosthesis at night may lead to further tooth surface loss.<sup>28</sup>

Preventive measures include instructing the patient in the application of 5000 ppm Fluoride toothpaste to the surface of the prosthesis before wearing. It has also been suggested that there may be some benefit to the application of chlorhexidine gel to the fitting surface of the denture in reducing bacteria associated with periodontal disease. However, these results only showed a short-term benefit and therefore the evidence is limited.<sup>34</sup> Both are dependent on good patient compliance, which is another reason why this patient group should be considered high risk for disease and therefore needs an appropriate recall period to reinforce oral hygiene measures and manage disease earlier. Studies have demonstrated that, where compliance with fluoride application is good, the development of caries is low compared with those patients who do not comply.<sup>31,35</sup>

## Conclusions

Whilst advances in adhesive dentistry and the availability and acceptance of dental implants have continued, there is still a place for the use of dentures in the management of toothwear in severe cases. Their use is relatively inexpensive compared with adhesive and conventional fixed prosthodontic techniques. Little or no preparation is required and, with the use of a transitional appliance, vertical and horizontal changes in jaw position can be rehabilitated, as well as assessing the

tolerance of a removable prosthesis. Missing teeth can also be easily replaced as part of the rehabilitation. The long-term success of the prosthesis and of the underlying teeth is determined by appropriate case selection, material choices and denture design, in conjunction with controlling the aetiological causes of the toothwear and installing a good maintenance programme. The patient needs to accept responsibility for excellent oral hygiene and attendance at review appointments for this approach to toothwear management to be a success.

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