

# Prosthetic Management of Severe Mandibular Deviation in a Hemi-Mandibulectomy Patient Following Osteoradionecrosis

## Keywords

Selective Laser Sintering  
3D Printing  
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## ABSTRACT

Rehabilitation of a patient after hemi-mandibulectomy without reconstruction represents a prosthodontic challenge. Indeed, mandibular deviation and decreased occlusal contacts are a common presentation post-surgery. This paper reports on a patient who presented with these challenges and where chronic osteoradionecrosis has resulted in significant mandibular deviation. A maxillary cobalt chrome mandibular deviation device, designed with palatal bite plane and constructed using 3D printing methods, resulted in a successful outcome. The authors aim to show how restorative management of similar patients can be successful using a modern approach.

## INTRODUCTION

### BACKGROUND

An 80-year old male was referred to the Restorative department at Cardiff Dental Hospital in 2018 regarding potential replacement of missing teeth in the upper left quadrant. He had previous squamous cell carcinoma of the tongue and floor of the mouth treated with surgical resection and postoperative radiotherapy in 2009. Following recurrent osteoradionecrosis of the left mandible the reconstruction plate was removed in 2017 leaving him with a mandibular discontinuity defect and associated mandibular deviation.

He presented complaining of jaw deviation to the left and experienced functional difficulties in chewing because only a few of his teeth were in contact, despite retaining most of his teeth. He had never worn a removable prosthesis and had enquired about dental implant treatment. Up until recently, he experienced extra oral discharge from a fistula of the lower border of the left mandible associated with osteoradionecrosis.

In addition to his cancer history, the patient's medical history included hypertension and gastric reflux. He was a non-smoker and had minimal alcohol intake.

### HISTORY AND EXAMINATION

On examination the patient had a non-tender swelling over the left body of the mandible with associated soft tissue scarring from an extra-oral fistula related to the osteoradionecrosis (Figure 1). There was limited mouth opening

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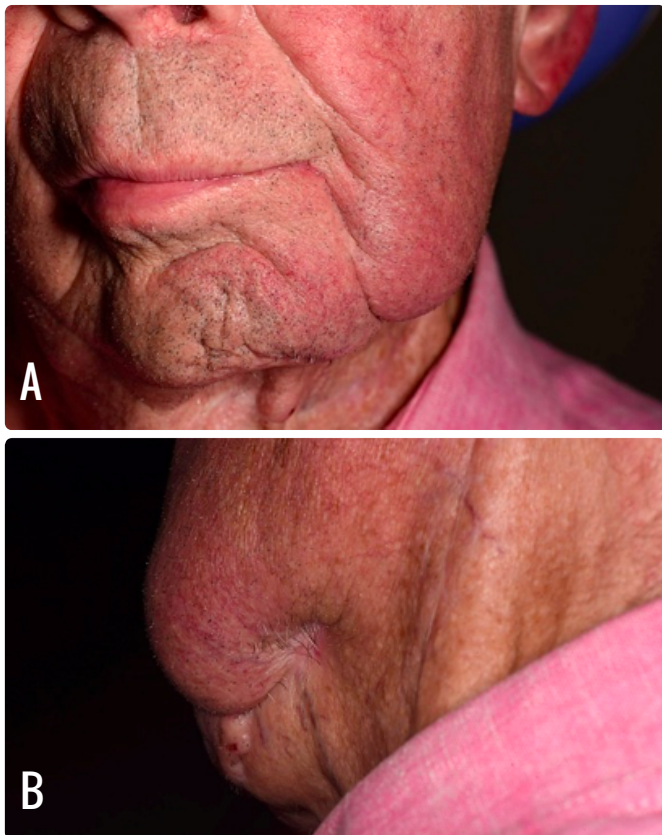
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with an interincisal distance of approximately 25 mm. Intraorally, his oral hygiene was poor and there was generalised staining, plaque and calculus with pocketing no greater than 6 mm (Figure 2). Apart from tooth 17 all teeth were firm. The 17 was grade III mobile with complete loss of hard and soft tissue over the apex. His mandibular deviation to the left side was extreme and measured approximately 15 mm from the centre line. The 16, 25 and 26 were missing. In the 25 and 26 region, there was a reduction of bone volume. The only occlusal contacts present were between the 24, 31 and 32 in intercuspal position even though twenty permanent teeth were present. Caries on the occlusal aspect of the 15 was visible. The patient had a favourable smile line. Radiographic examination revealed left mandibular fracture with osteoradionecrosis (Figure 3).

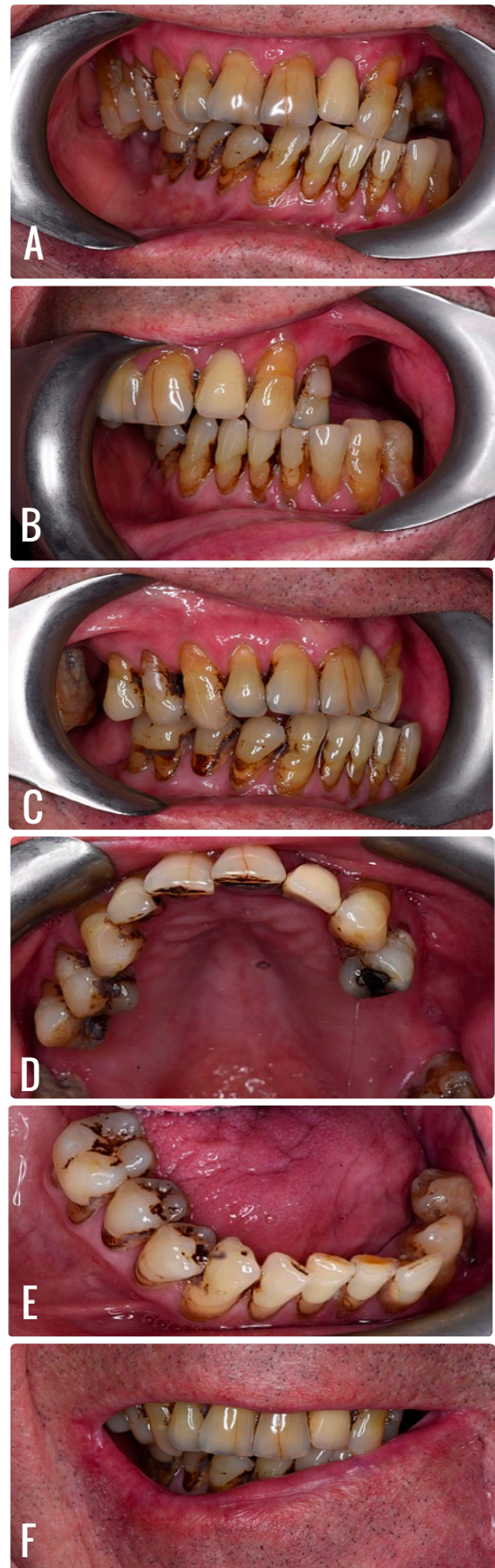
## DIAGNOSIS

Based on the findings, the following diagnoses were made:

1. Mandibular deviation with inadequate occlusal contacts.
2. Acquired tooth loss 16, 25 and 26.
3. Pathologic left mandibular fracture with osteoradionecrosis (Type III).<sup>1</sup>
4. Localised periodontitis; Stage 4 Grade C (Tooth 17)
5. Generalised Periodontitis; Stage 2 Grade B (currently unstable – risk factors poor oral hygiene)
6. Failing restoration 15.



**Figure 1:** Pre-operative extraoral views of the left body of the mandible illustrating soft tissue swelling and scarring from extra-oral fistula. A): Anterior view B) Lateral view.



**Figure 2:** Preoperative intraoral views illustrating mandibular deviation to the left and limited occlusal contacts. A) Anterior view. B) Left Buccal view. C) Right Buccal view. D) Maxillary Occlusal view. E) Mandibular Occlusal view. F) Smile view.



**Figure 3:** OPT illustrating fracture of the left mandible with osteoradionecrosis.

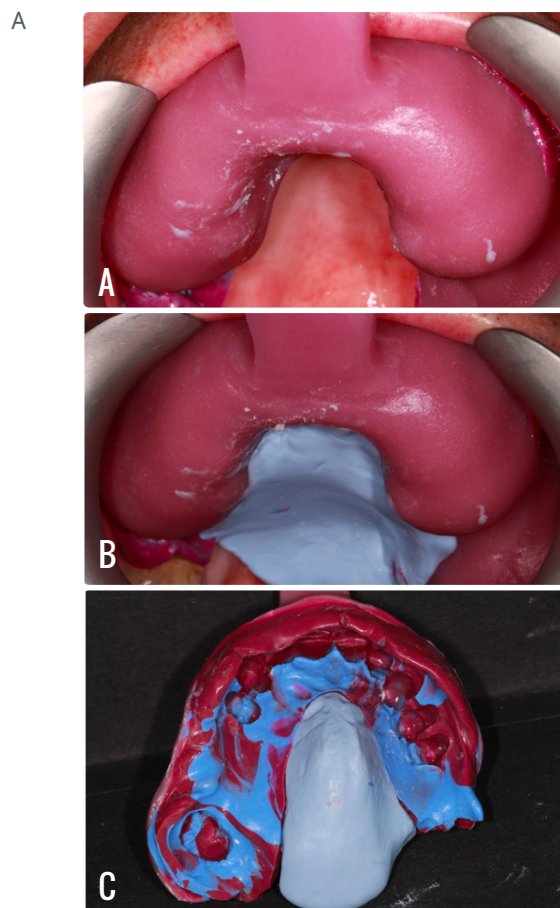
## MANAGEMENT

The relatively high risk of implant treatment was discussed with the patient in view of his medical history and osteoradionecrosis. A treatment planning decision was therefore made to construct a removable appliance. Management initially involved prevention and stabilisation therapy which included:

1. comprehensive periodontal examination, oral hygiene instruction and non-surgical periodontal treatment and
2. restoration of the 15. Extraction of the 17 was advised however the patient requested to monitor the tooth as he was asymptomatic.

Following the stabilisation phase, a maxillary cobalt-chrome 3D-printed mandibular deviation appliance was planned. For the initial impression, a stock tray with alginate (Kromopan) and compound (Kemco) was used. There was difficulty in capturing the full extent of the patient's dentition and palate due to the reduced oral opening and high palatal vault. Therefore, a two-part impression was taken to enable fabrication of a more accurate primary cast (*Figure 4*). A light (Extrude Wash) and medium bodied (Aquasil Ultra Monophase) silicone impression was taken with a horseshoe-shaped special tray. Once the impression set, a putty (Aquasil Soft Putty) impression of the palate was taken over the special tray. Vaseline was applied beforehand to allow removal of the putty impression separately.

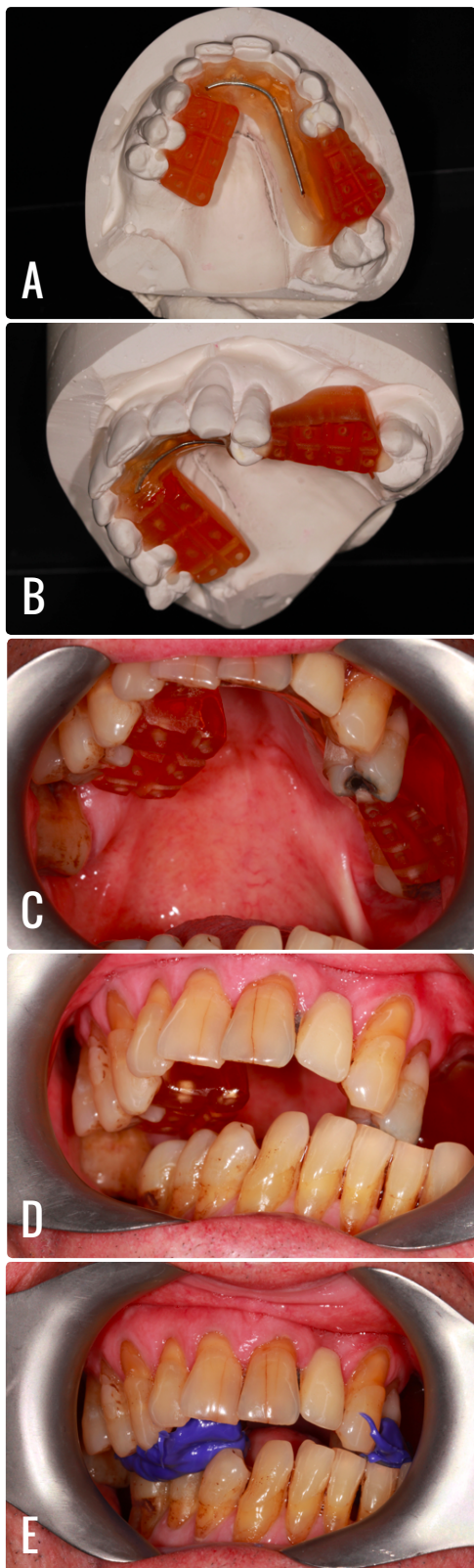
The primary casts were articulated using an occlusal wax rim record in centric relation as the primary jaw registration. The casts were surveyed and this revealed an absence of buccal undercuts for retentive clasping. Buccal composite restorations (Spectrum) were therefore placed on the maxillary premolar teeth in an attempt to create undercuts. This was unsuccessful as the teeth were too palatally inclined. There was however, 0.25 mm of undercut found interproximally. The decision was therefore made to utilise these buccal undercuts present interproximally, using Cobalt Chromium occlusally approaching clasps. Whilst it is acknowledged that the insufficient undercut would put additional stress on the clasp however, options were limited. A master impression was subsequently undertaken with extra light (Aquasil Ultra XLV) and medium bodied silicone (Aquasil Ultra Monophase) impression using a special tray. The special tray had a horseshoe-shaped design that extended further onto the palate.



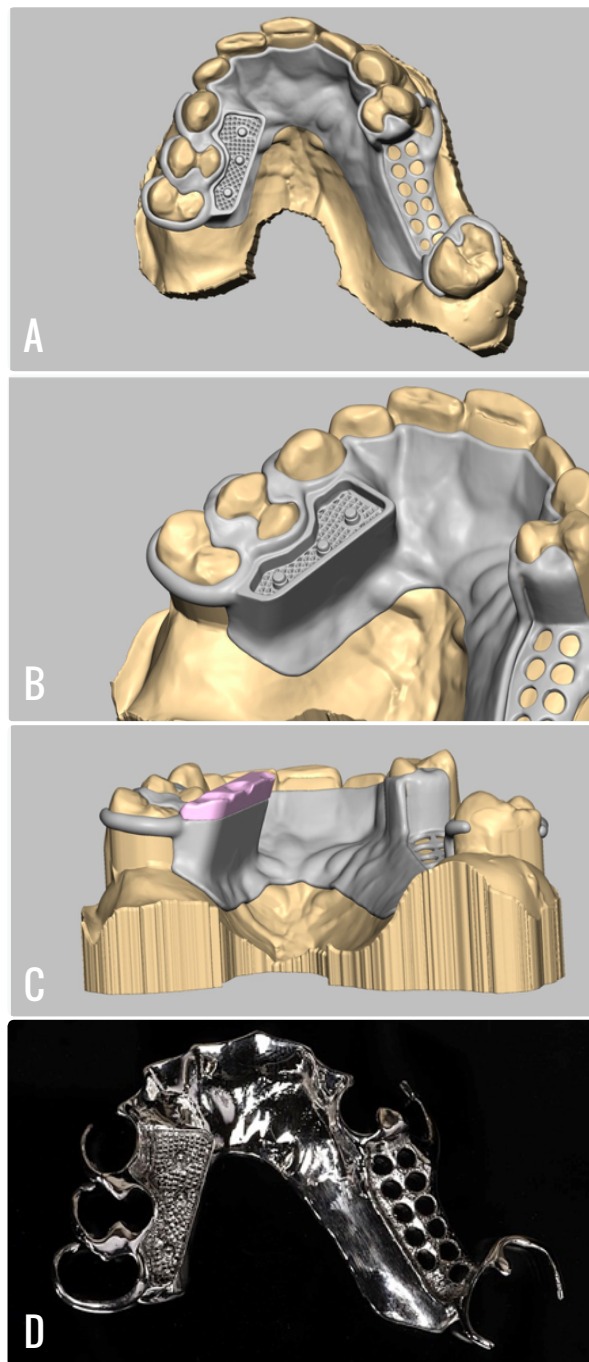
**Figure 4:** Intraoral views illustrating the two-part impression technique. A) Maxillary special tray in situ with light and medium bodied silicone impression material. B) Maxillary special tray impression in situ with putty over palate. C) Complete impression using light and medium bodied silicone with putty over palatal region.

3D-printed occlusal registration block was designed using the Freeform plus™ computer software (Geomagic®) and fabricated in resin (SG resin) using a 3D printer (Formlabs Form 2). A wire strengthener was integrated into the block using light cure acrylic. The occlusion was registered in centric relation using occlusal registration paste (Aquasil Bite) over the bite block (*Figure 5*). The maxillary cobalt chrome mandibular deviation appliance was subsequently constructed using 3D CAD-CAM direct metal laser sintering (*Figures 6 and 7*). Design of the cobalt chrome framework was first carried out using the Freeform plus™ computer software (Geomagic®) (*Figure 6*). The design included a cobalt chrome bite platform which was sloped medially towards the occlusal plane to allow space for tongue function. Occlusally approaching clasps were designed to engage the retentive undercuts interproximally. The final design was sent electronically to the manufacturer (Renishaw plc) for fabrication using the direct metal laser sintering process.

Once the framework was received from the manufacturer, a palatal acrylic bite platform was incorporated on the right-hand side. The fit of the framework and occlusion was



**Figure 5:** Occlusal registration using 3D printed resin (SG Resin) registration block. A) Occlusal view of resin registration block with integrated wire strengthener on maxillary cast. B) Lateral view of resin registration block with integrated wire strengthener on maxillary cast. C) Resin registration block in situ – occlusal view. D) Resin registration block in situ – anterior view. E) Resin registration block in situ with registration paste used to record centric relation.



**Figure 6:** CAD-CAM design of maxillary cobalt chrome mandibular deviation appliance framework. A) Maxillary occlusal view of CAD-CAM design. B) Lateral-maxillary occlusal view of CAD-CAM design. C) Posterior view of CAD-CAM design. D) 3-D Printed metal framework.

checked intraorally and the tooth positions for the UL5 and UL6 were prescribed using an occlusal wax rim (Figure 7). A tooth-try in was performed before fitting the final appliance. At the time of the fit, the patient was satisfied with the retention, stability and aesthetics of the appliance. Balanced occlusal contacts were achieved with the palatal acrylic bite plane and increased occlusal table of the UL5 and UL6. The final outcome of the treatment is illustrated in Figures 8 and 9.



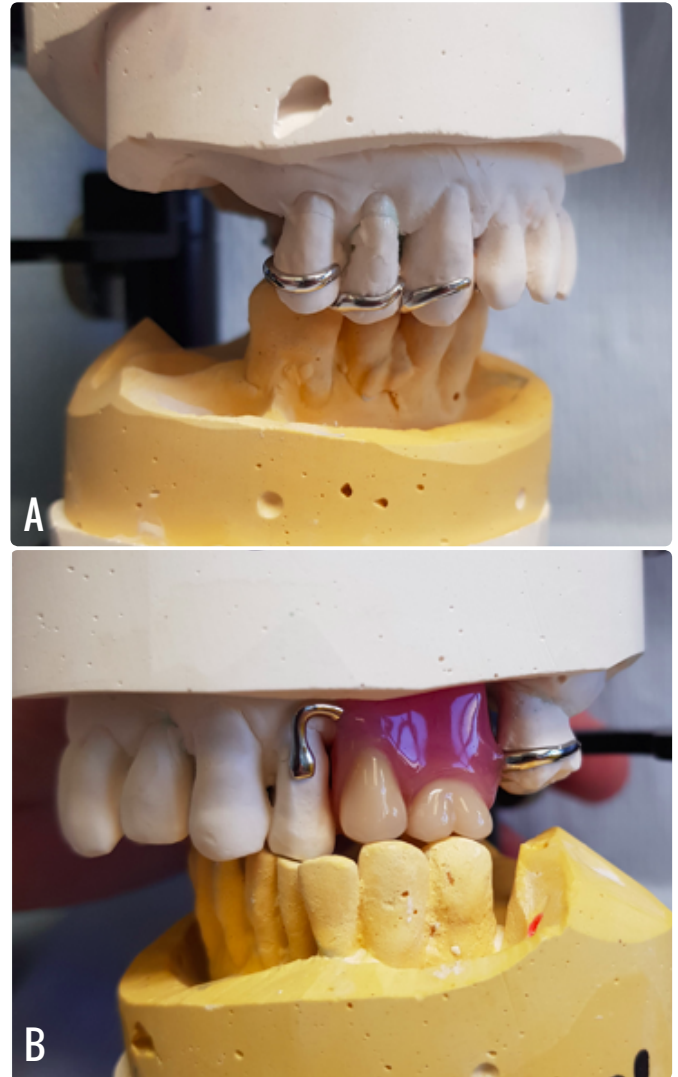
**Figure 7:** Cobalt chrome framework try-in. A) Metal framework in situ with right hand side palatal acrylic bite platform and left hand side wax to allow accurate recording of 25 and 26 position. B) Extent of left sided mandibular deviation at 18mm with Cobalt Chromium try in and attached left hand side wax record in situ.

## REVIEW & FOLLOW-UP

At his three month review, the patient was very pleased with the overall outcome of the treatment in terms of function and aesthetics. He reported being able to eat a wider range of foods when wearing the appliance. A one-year review has subsequently been arranged.

## DISCUSSION

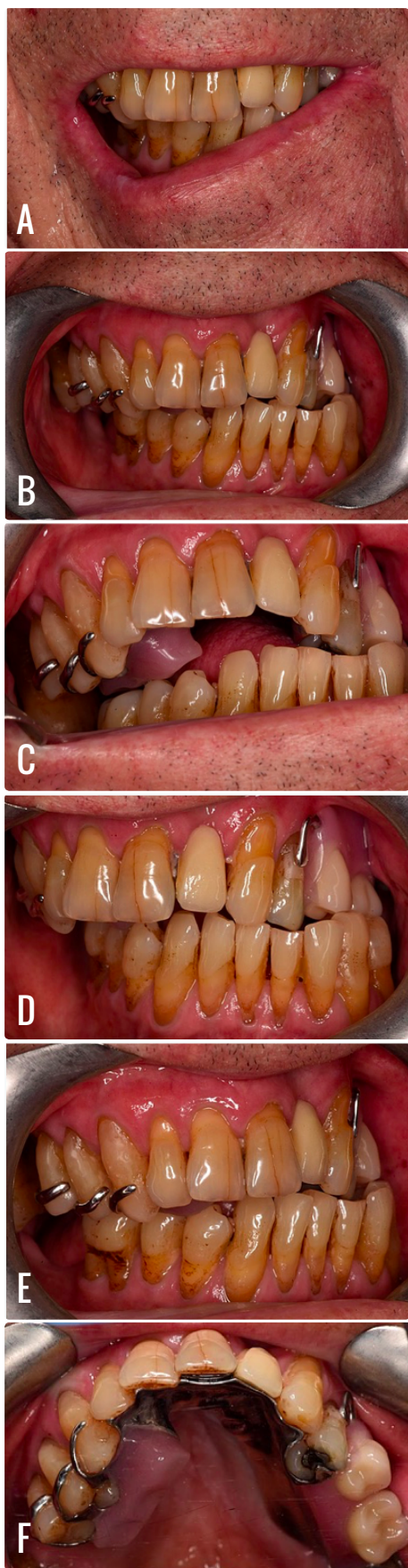
The current evidence base supports the decision made in this case to accept the compromised maxillomandibular relationship and adopt a conservative restorative approach using a removable appliance. A fixed implant option was unfavourable due to the limited application in increasing the number of occlusal contacts as well as the patient's high risk of ORN and lack of bone volume. The option for mandibular guidance therapy was also deemed unsuitable due to the amount of time that had elapsed since the surgical procedure. Consideration was also given to the future maintenance and management requirements for the patient. The treatment provided was seen to be a realistic and reasonable option for the



**Figure 8:** Mandibular deviation appliance on articulated study casts. A) Right lateral view of occlusally approaching clasps engaging into interproximal undercuts. B) Left lateral view of deviation device on articulated study casts

patient and general dental practitioner to maintain. These include: (1) ease of insertion and removal of the appliance (2) access for oral hygiene and periodontal maintenance (3) repair and maintenance of the appliance and (4) addition of teeth to the prosthesis if teeth require extraction in the future.

This case report demonstrates the important role of CAD-CAM 3D printed technology for providing a successful outcome for the patient. At the time of appliance construction, the University Dental Hospital of Cardiff had a unique position in the United Kingdom as it had an in-house laboratory suite for CAD-CAM design of oral and maxillofacial prostheses and 3D laser acrylic printing. The decision to construct a 3D printed occlusal registration block proved advantageous as this was quick, accurate and straightforward to fabricate. Intraorally, the block had exceptional stability and retention and therefore prevented displacement during the occlusal registration procedure. It is in the authors' opinion that a conventional occlusal wax rim would not have matched the stability and retention that the 3D printed block offered and therefore



**Figure 9:** Post-operative intraoral views of mandibular deviation appliance. A) Smile view. B) Anterior view. C) Anterior-inferior view with palatal bite platform in view. D) Left buccal view. E) Right buccal view. F) Maxillary occlusal view.

could have led to inaccuracies during the occlusal registration procedure. There are specific reasons for the decision to construct the cobalt chrome framework using CAD-CAM 3D printing technology. At the University Dental Hospital of Cardiff, cobalt chrome frameworks are routinely fabricated using this technology. The technical quality is anecdotally reported by clinicians to be superior in terms of fit and accuracy compared to conventional cobalt chrome cast frameworks, thus leading to better patient and clinician satisfaction. The process is also more reliable as no casting errors are encountered, which is a risk with conventional cobalt chrome framework fabrication. The benefits of CAD-CAM 3D printing technology are discussed in further detail in a later section.

## MANDIBULAR DEVIATION

Mandibular deviation is often seen after hemi-mandibulectomy surgery. In this case, after part of the mandible was removed, the residual segment gradually rotated inferiorly and mesially towards the resected side.<sup>2</sup> Loss of mandibular continuity and muscle attachments on the resected side, together with the remaining musculature on the unaffected side, encourages the mandible to rotate. Preservation or loss of mandibular continuity, extent of surgical defect, presence of condyle on the resected side, speed of healing and patient cooperation are all factors in the severity of deviation.

The altered maxillary-mandibular relationship impacts neuromuscular control affecting masticatory ability, speech intelligibility, saliva control and facial asymmetry. Patients will often present with decreased mouth opening and open bite as the deviation progresses.<sup>3</sup> Returning this type of patient back to successful function represents a significant challenge to the prosthodontist or restorative dentist.

## MANAGEMENT OF MANDIBULAR DEVIATION

Mandibular guidance therapy can be initiated as early as two weeks post-surgery to prevent and reduce the extent of future deviation using the following interventions:<sup>4</sup>

- Jaw exercises to improve mouth opening and encourage the mandible towards the non-resected side;
- Frequent chewing gum usage; and/or
- Interim maxillary guidance ramp: helps prevent scar tissue contracture whilst being away from the surgical site so does not affect healing.<sup>5</sup>

## Non-surgical rehabilitation

Should surgical reconstruction not be pursued, perhaps due to patient choice; previous failed reconstruction and/or chronic osteoradionecrosis, then naturally a non-surgical approach is adopted for oral rehabilitation. A removable denture can be constructed and occlusal discrepancies addressed with guiding flange. This encourages the mandible to return to the original centric occlusal position. Common design features of

a guiding flange prosthesis include increased rows of teeth; cuspal interlocking; and/or increased occlusal table. However, there may be scenarios when guiding the mandible into a favourable position with a guidance appliance is not possible. In this case a deviation appliance, accepting the jaw position, was constructed to increase occlusal contact. Increasing the number and surface area of occlusal units improves masticatory function and as such, prevents further deviation and palatal trauma.<sup>6</sup>

If surgical reconstruction is not possible, mandibular alignment is significantly more demanding. Indeed, a comfortable mandibular-maxillary relationship may never be totally achieved. Yet despite this there are benefits to a non-surgical approach as it is cost effective and less time intensive which patients may appreciate.

### Surgical rehabilitation

Conventional mandibular reconstruction of cancer defects may involve using a flap or graft with or without hard tissue reconstruction.<sup>7</sup> Free flap surgery is the most common approach and the gold standard in surgical treatment of head and neck cancers.<sup>8-9</sup> Fixed prostheses such as dental implants are often placed at least one year after surgery to allow time for healing and render reconstructive success more likely. Notably, the literature suggests that only 12% of dentate patients who have reconstructive surgery then go on to receive dental implants. For edentulous patients, this number decreases to just 7%.<sup>7</sup> Decreased rate of implant placement, may be due to patients' reluctance to undergo further elective surgery after having already undergone such invasive and life changing treatment. As part of the analysis of these low rates, one must consider the survival rate for those affected by head and neck cancer. Indeed, approximately half of these patients never reach the point of prosthetic rehabilitation.<sup>7</sup> There may also be clinical reasons as to why implants are not indicated as is the case with this patient, who suffered from chronic osteoradionecrosis and previous failure of reconstructive plate requiring removal.

### OSTEORADIONECROSIS

Osteoradionecrosis (ORN) was first discussed by Regaud in 1922 and later by Ewing using the term 'radiation osteitis'.<sup>10-11</sup> In 1974, Guttenburg described septic osteoradionecrosis of the mandible.<sup>11</sup> A more commonly known definition is that of Marx in 1983, who described ORN as an area of >1 cm of exposed bone in the field of irradiation that fails to show any evidence of healing for 6 months or more.<sup>13-14</sup> Later descriptions are similar, however they suggest a shorter history of exposed bone lasting more than 3 months compared to the 6 months suggested by Marx.<sup>15-16</sup> More recent literature has not specified a timeframe and instead focuses on the ischaemic necrosis occurring in the absence of metastatic disease or tumour recurrence.<sup>17</sup> UK Multidisciplinary National Guidelines published in 2016 define ORN as 'hypovascularity and necrosis of bone followed by trauma induced or spontaneous mucosal

breakdown leading to a non-healing wound'.<sup>18</sup> Whereas RD-UK guidance from 2016 describes an area of exposed bone of at least 3 months duration in an irradiated site which is not due to the original tumour recurrence.<sup>19</sup> There is no clear agreement in the literature regarding specific aspects of ORN such as timeframe, size of lesion and radiographic appearance. Nevertheless, there is a general consensus that ORN is defined as a previously irradiated area of necrotic bone with mucosal breakdown not caused by tumour recurrence or malignancy present for at least 3 months.

Incidence of spontaneous ORN after head and neck radiotherapy is reported as approximately 2%<sup>20</sup> However, some have placed this figure as high as 5.2%.<sup>19</sup> If a tooth is extracted from previously irradiated tissues, the likelihood of ORN occurring increases to 7%.<sup>21</sup> Notably, this figure does not increase or decrease dependent on timeframe from the radiation episode. Tooth extraction anytime after radiation carries a significant risk of ORN. There is some weak evidence to say that less ORN now occurs due to the advent of more modern radiation techniques such as Intensity Modulated Radiation Therapy (IMRT).<sup>20</sup> Indeed, when compared with conventional radiotherapy, IMRT is much better at achieving target coverage and avoiding healthy tissues. There is a need for more thorough investigation into whether IMRT reduces the risk of ORN. IMRT has however been shown to significantly reduce post-operative problems such as xerostomia and restricted opening.<sup>19</sup>

Intra-oral presentation of ORN often shows an area of unhealing mucosa, with or without visible exposed bone and associated soft tissue swelling and erythema. If the ORN is more advanced, discharging oro-cutaneous fistula may be present with limited mouth opening, lymphadenopathy and/or paresthesia. If left untreated, pathological fracture of the mandible may occur.<sup>22</sup> Radiographic imaging may show osteolysis and sclerosis of the affected area with possible sequestration and thinning of the cortical bone. Loss of trabeculated pattern is often seen with widening of periodontal ligament space of any remaining teeth. An initial OPT can give a simple idea of the pathology location, however a further CT Scan is needed to visualise the extent and severity of the disease. Several grading systems have been developed and explained comprehensively in the literature. Marx introduced a staging system centred around the tissues response to hyperbaric oxygen.<sup>14</sup> This theory was then superseded by Epstein, who considered the presence of pathological fracture and jaw dysfunction as key to staging.<sup>23</sup> More recently, Notani's classification has been developed and is now widely used.<sup>1</sup>

Notani Classification of ORN Grading:

1. ORN confined to bone.
2. ORN limited to the alveolar bone and/or mandible above the level of the inferior alveolar canal.
3. ORN involving the mandible below the level of the inferior alveolar canal and/or skin fistula and/or pathological fracture.

Several theories have been put forward as to how ORN develops. Marx introduced the hypocellular, hypovascular and hypoxia theory as a cause for ORN.<sup>13</sup> It centres around the idea that radiation causes swelling, degeneration and eventual death of the inner endothelial lining of small arteries and arterioles. Formation of thrombi causes vascular congestion and decreased blood flow. Over time, microvascular structures can become occluded meaning crucial metabolites fail to reach irradiated tissues. In addition, increased fibroblastic activity leads to fibrosis of tissues. Eventually the inferior alveolar artery can become occluded which is crucial for any metabolite delivery to the mandibular area, as it is the exclusive provider of sustenance to these tissues. Without this vascular supply, tissues struggle to maintain previous levels of cellular turnover and become hypoxic, hypocellular, hypovascular and ultimately, necrotic. More recently and in contrast to Marx' theory, a new idea has emerged which is referred to as the fibro-atrophic theory.<sup>24</sup> This focuses on the idea that radiation damage to osteoclasts occurs much earlier than vascular tissue changes. In turn, osteoclastic damage leads to a decrease in fibroblastic activity and lack of collagen secretion. As such, meaning that atrophic tissue becomes extremely fragile and even mild local trauma risks inflammatory reactivation within tissues.

ORN is recognised as a significant and real complication of head and neck radiotherapy.<sup>25</sup> Recognised risk factors for developing the condition include:

- Dosage: radiation over 60Gy is widely agreed to increase ORN risk significantly.<sup>21</sup>
- Trauma to radiation area such as tooth extraction or implant placement.<sup>26-27</sup>
- Treatment field size.
- Type of energy used.
- Accelerated fractionation with or without increased dosage.<sup>20</sup>
- Volume of irradiated tissue.<sup>28</sup>
- The posterior part of the mandible is a common site of ORN due to its dense bony nature.<sup>29-30</sup>
- Pre-existing periodontal disease.<sup>22</sup>
- Dentate patients.<sup>22</sup>
- Tumour proximity to overlying bone (for example, ORN risk is increased if only a thin layer of mucosa remains over the bone post-surgery).
- Patient related factors (for example poor oral hygiene, old age, smoking, nutritional status, systemic diseases).<sup>31</sup>

Between 70-94% of ORN cases will develop within 36 months of radiation therapy.<sup>32</sup>

There is no singular approach for the management of ORN with a number of options that vary depending on severity, extent of disease progression and individual patient factors.<sup>18,21,33</sup>

Most sources agree that conservative management is to be employed for mild localised cases of ORN in the form of:

- Irrigation with saline and chlorhexidine.
- Minor debridement.
- Sequestrectomy.
- Long term broad spectrum antimicrobials.
- Smoking cessation.

Options discussed in the literature for management of more advanced ORN are:

- Hyperbaric Oxygen Therapy (HBO).
- Pentoxifylline combined with Tocopherol and/or Clodronate (Bisphosphonate).
- Radical ablative surgery to remove diseased hard and soft tissue with possible reconstruction.

HBO involves often 30-40 sessions in an oxygen chamber for 90 minutes each session. The oxygen is thought to increase fibroblast activity and angiogenesis in hypoxic tissue. HBO has been found to have a significant benefit for the prevention of ORN.<sup>34</sup> However research has shown its effect on the management of ORN to be insignificant.<sup>35-36</sup> NICE and RD-UK have highlighted the uncertainty as to whether HBO has any significant effect as a treatment for ORN and the need for more good quality research on the topic.<sup>19,33</sup> Indeed, NICE suggests that at present, the use of HBO should only be used as part of a clinical trial in order to gain more knowledge on its efficacy.<sup>33</sup> The British Society for Disability and Oral Health and the Royal College of Surgeons agree that HBO should only be used within a clinical trial environment and suggest it currently only has a role if used together with surgical intervention.<sup>37</sup> Other authoritative sources state similarly that the effect of HBO remains unproven.<sup>18</sup> A clinical trial assessing the use of HBO in combination with surgical removal of necrotic bone has been completed and the results, when published, should give a clearer picture on the subject.<sup>30</sup>

The use of clodronate in combination with pentoxifylline-tocopherol for treatment of ORN is becoming increasingly more common. Pentoxifylline-tocopherol is a vasodilator believed to facilitate microcirculation and fibroblast activity and clodronate is a bisphosphonate. There is limited good quality evidence available for this relatively new management method.<sup>18,33</sup> However, a small clinical trial of 18 patients with extensive mandibular ORN found pentoxifylline-tocopherol with clodronate had significant positive results. Indeed, 16 patients recovered completely after 6 months.<sup>18,33,39</sup> These relatively new medications appear to be well tolerated, conservative and beneficial, particularly if used early enough in the disease process.<sup>21,33</sup> All sources agree that more good quality research is required for any strong conclusions to be reached.

Severe cases involving full thickness necrosis, oro-cutaneous fistula and/or mandibular fracture may require resection and immediate or later reconstruction with vascularised tissue.

Bettoni *et al.* (2019) found bone resection and immediate reconstructive surgery had a 92.3% success rate. However, this study was small (55 operations), retrospective and single centre.<sup>40</sup> That said, guidelines agree that radical ablative surgery is appropriate if ORN is advanced.<sup>18,33</sup> Some ablative surgical defects are left without reconstruction and therefore produce deviation as in the presented case.

## LASER SINTERING

3D printing has a clear role in dentistry, as it allows rapid, accurate production of prostheses and achieves the fine detail required. Indeed, it has been described as the future of dentistry, as a potentially cheaper and quicker alternative to more traditional methods of prostheses production.<sup>41</sup>

3D printing is also referred to as “additive processing”. Using digital imagery and information, it builds a 3D object from successively adding material layer upon layer.<sup>42</sup> Hence the name additive processing, as it repeatedly adds slices of 2D information to make a final 3D object. Selective laser sintering (SLS) and selective laser melting (SLM) are both additive manufacturing techniques. They involve reflecting a laser off a mirror onto extremely fine particles of powdered material. The powder is either sintered or melted together layer after layer and as the laser continues to fire, a final 3D object is created. SLS and SLM are similar processes, however SLM material is melted together as opposed to sintered allowing for different final properties. These additive processes contrast to other modern subtractive techniques like milling, which starts with a block of material and cuts away as per the digital information received to create the final object.<sup>43</sup> The denture in this report was made in a unit using SLS.

There are several advantages of using laser sintering over more traditional methods. 3D printing arguably produces a higher level of accuracy than other methods and if data is saved, prostheses are readily reproducible if lost.<sup>44</sup> Using 3D printing reduces risk of errors commonly seen in waxing and casting techniques. Prostheses made in this modern way reduce waste and can be manufactured much quicker than those made using older, more lengthy processes.<sup>45</sup> Although initial start-up costs for laser sintering are high and operator training is required, ongoing costs are low as the first prosthesis costs the same as the last. Critics of this technology suggest that the software may not be able to achieve complicated and less routine designs such as splitting and swing lock clasps.<sup>46</sup> However, our unit has successfully produced swing lock dentures using this technique.

3D printing in dentistry is becoming more common, particularly with fixed prostheses. Indeed, considering the relatively short time these techniques have been available, the literature covers implants and crowns well.<sup>44-48</sup> However, less is found in the literature discussing SLS in a denture construction context.

In fact, the authors found very little evidence available comparing casting, milling and SLS techniques for denture construction. Instead, the literature focuses on comparing metal alloy properties by their construction method; traditional casting, milling or SLS. Indeed, metal alloys used in fixed prosthodontics have the highest tensile strength if milled and the highest yield stress if laser sintered.<sup>48</sup> Similarly, SLS made alloys for removable dentures have been found to have better adaptation, with slightly less casting defects and a denser microstructure.<sup>49</sup> However, this was found as part of very small study which itself called for more research on the topic. Kanazawa found SLS frameworks to be harder and denser than those made via castings and Afify suggests that digital technology should be used to enhance wear and fracture resistance of dentures where necessary.<sup>43,50</sup> From the limited evidence available, it is clear that SLS certainly has a place in modern denture construction with some suggesting its superiority to traditional methods.<sup>51,52</sup>

## CONCLUSION

This case report aims to demonstrate how prosthetic management of a patient post hemi-mandibulectomy can be successful. The use of 3D printing in removable partial denture design is evolving and may enable higher levels of accuracy when constructing prostheses in challenging cases such as this.

## MANUFACTURERS' DETAILS

- Kromopan alginate impression material (Lascod, Italy).
- Kemco impression compound material (Kemdent, UK).
- Extrude Wash silicone impression material (Kerr, USA).
- Aquasil Monophase silicone impression material (Dentsply, USA).
- Aquasil Ultra XLV silicone impression material (Dentsply, USA).
- Aquasil Soft Putty silicone impression material (Dentsply, USA).
- Surgical Guide Resin (Formlabs, USA).
- Aquasil Bite registration paste (Dentsply, USA).

## ACKNOWLEDGEMENTS

Paul Clark, Chief Dental Prosthetic Technologist, Cardiff University Dental Hospital.

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