

The restorative management of tooth wear involving the aesthetic zone

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Key points

Outlines the protocol for carrying out a systematic assessment of the aesthetic zone for a patient with toothwear.

Describes the clinical techniques for helping to establish a predictable aesthetic-functional outcome when attempting to restore worn down teeth in the aesthetic zone.

Overviews the data for the success and survival of restorations/restorative materials used to manage tooth wear affecting the aesthetic zone.

The aim of this article is to describe a systematic approach that facilitates the establishment of a clear and appropriate diagnosis when a dentate patient presents with tooth wear involving their aesthetic zone. It will also detail the protocols that are required to allow for the development of an acceptable aesthetic prescription within the limits of the functional constraints presented by the patient (where active restorative intervention may be indicated), as well as to communicate the manner by which this information can be transferred to ultimately enable the successful and predictable rehabilitation of the affected areas. An overview will also be provided of the tooth-coloured dental materials and restorative techniques that have been commonly applied to deliver the predictable and effective dental care of worn teeth in the aesthetic zone.

Introduction

The term aesthetic zone (also known as the smile zone) is frequently applied in the dental literature, and is used to refer to all of the hard and soft tissues that are visible when the patient makes a broad smile.¹ Among more severe cases of tooth wear, the effects of the aetiological processes leading to the irreversible loss of the dental hard tissues can have a dramatic effect upon the patient's aesthetic zone, as shown in Figure 1.

Given the increasing prevalence of tooth wear, with the UK Adult Dental Health Survey of 2009 reporting 77% of the 6,469 participants examined showing signs of tooth wear at their anterior teeth (compared with 66% in 1989),² it is likely that dental practitioners will be seeing



Fig. 1 An example of a patient with severe tooth wear. This patient unsurprisingly, presented complaining with concerns primarily relating to their aesthetic appearance

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a steady increase in patients presenting with tooth wear, with specific concerns relating to the effects of tooth wear on their oro-facial appearance. This aspect was emphasised as part a study by Wazani *et al.*³ involving the retrospective evaluation of the clinical records of approximately 300 patients referred to a UK-based University Dental Hospital for the condition of tooth wear. Aesthetic concerns

were reported to be the most prevalent cause for the presenting complaint (59%), followed by sensitivity (40%), functional problems (17%) and pain (14%). Similar outcomes in relation to impact of alterations in dental appearance were reported by Al-Omiri *et al.*,⁴ with aesthetic concerns being the most likely presenting complaint for patients suffering from the effects of tooth wear.

While there may in fact be valid reasons to account for the above observations,³ the actual impact of tooth wear upon the quality of life of an adult dental patient (especially when of the more severe variety) should not be underestimated.⁵ Therefore, given the role of an individual's smile (not only as an overall determinant of facial appearance but also with other key human functions – inclusive of non-verbal communication),^{6,7} it is not infrequent for restorative rehabilitation to be sought and indeed prescribed for such patients.

Unfortunately, the successful undertaking of the restorative rehabilitation of the aesthetic zone for a patient affected by tooth wear can itself prove to be very challenging. This may be attributable to a multitude of factors, which are likely to include the frequent absence/presence of limited reference guides to direct restorative treatment (specifically in relation to the size, shape and proportions of the dentition) towards that which would have existed in the pre-worn dentition, as seen by the example of Figure 1, as well as by the challenges that exist when attempting to define the 'aesthetic dental ideal.' The latter is due in part to the subjective nature of the concept of beauty.

The contemporary dental practitioner must develop a good understanding of the 'universally accepted concepts of dental aesthetics' (the perception of what is considered to be generally aesthetically pleasing among dental professionals and lay people respectively) when attempting to undertake restorative rehabilitation of the aesthetic zone for patients with tooth wear.¹ The universal concepts in dental aesthetics have been summarised in Box 1. The application of the universal concepts will be described later in this article. This can be used to determine an appropriate aesthetic prescription when planning restorative rehabilitation.

Evaluation of the aesthetic zone; patient examination

The patient's chief complaint must be initially evaluated, including any specific aesthetic concerns.⁸ In general, dental aesthetic concerns relate to anomalies in tooth; colour, position and/or shape.⁹ It can sometimes be beneficial to present the patient with a pre-treatment aesthetic evaluation form before the first appointment to gain a further insight to their specific concerns.¹⁰

Examination of the aesthetic zone for a patient with tooth wear should logically commence with an appraisal of the extra-oral features (inclusive of the facial features).

When viewed in the frontal direction, the human face can be divided into three zones; the 'upper', 'middle' and 'lower third' respectively.¹¹ It is the lower third region (which includes the area between the interalar line and the tip of the chin) that not only appears to be the most significant in determining the overall facial appearance, but may also become adversely effected as a consequence of severe tooth wear, with the occasional concomitant loss of occlusal vertical dimension (OVD). The lower third is the only facial portion over which the dental operator has any significant influence. The loss of OVD may also affect patient function, comfort and aesthetics.¹² It is therefore appropriate to determine the magnitude of OVD loss. The latter is traditionally accomplished with the use of a set of callipers or a Willis Gauge; alternative techniques have been described that may offer a greater level of accuracy with this assessment.¹³

When considering facial symmetry, the facial midline and the interpupillary lines are the traditionally applied vertical and horizontal reference planes respectively. The interpupillary line provides the operator with a key reference axis in determining the ultimate position of the incisal, gingival and occlusal planes respectively, which may prove highly relevant in a patient displaying anterior tooth wear in helping to plan restorative rehabilitation.

The lateral facial profile is ideally assessed with the patient adopting a natural head posture. Three forms of facial profile have been described, hence; a 'normal profile', 'convex profile' or 'concave profile'.¹¹

In relation to the facial shape, classically four types of basic facial shape have been documented, hence; ovoid, square, tapering, square-tapering. This classification (Leon Williams Classification) has historically been used to determine appropriate moulds for removable denture prosthesis – albeit on a purely arbitrary basis. More recently however, four typological categories have been described, which may be applied to ascribe a particular facial shape to.¹⁴ The application of such concepts to the worn dentition may help the plan the ultimate morphological outcome when planning to carry

out the restorative rehabilitation of the worn dentition involving the anterior teeth, where in some cases, there may be little available clue to the original tooth form (such as archive) close up photographs.

The rest position of the lips has been traditionally used to ascertain the ultimate position of the incisal edges of the anterior maxillary teeth when undertaking complete denture prosthetics. The average ranges for tooth display at rest according to age have been determined as:¹⁵

- Aged 30 years: 3.0–3.5 mm
- Aged 50 years: 1.0–1.5 mm
- Aged 70 years: 0.0–0.5 mm.

The above values may serve as useful guidelines particularly when contemplating the lengthening of the incisal edges using fixed prosthodontic means, as may be the case when managing the worn anterior dentition.

Analysis of the intra-oral components of aesthetic zone should follow the extra-oral appraisal and aim to evaluate the following features:

The dento-labial relationships

The term 'lip line' or 'smile line' can be used to describe the relationship that exists between the inferior border of the upper lip and the teeth and gingival soft tissues on smiling (or when asked to make the 'E' sound [in English]). Three types of lip line are commonly described:

- 'Low smile line' – where the motility of the upper lip exposes the anterior teeth by no more than 75%, with no display of gingival tissue,
- 'Medium smile line' where lip movement culminates in the display of between 75% and 100% of the anterior teeth as well as the interdental papillae,
- 'High smile line', which exposes the teeth in full in display as well as the gingival tissues beyond the gingival margins, often referred to as a 'gummy smile'.

The 'width of the smile' should also be analysed. For optimum aesthetics, the dental hard tissues should fill the corners of the

Box 1 The universal concepts in dental aesthetics

- The elimination of disease and pathology
- The need to develop symmetry, proportion and harmony
- An appreciation of tooth/teeth position and dental morphology
- An appreciation of colour variations
- An appreciation of form



Fig. 2 An extra-oral view of the case included in Figure 1. Note the discrepancy in the 'smile arc' as a consequence of the effects of tooth wear

avoiding the presence of 'negative buccal corridors.' The 'smile arc' should also be evaluated; this describes the relationship that exists between curvatures of the lower lip to the curvature of the incisal edges of the maxillary incisor teeth in a posed smile. Ideally, the curvature of the lower lip should be parallel to that of the incisor edges and the superior border of the lower lip be spatially positioned slightly inferior to the incisal edges. The use of this information can be used to plan the appropriate design of any future restorations especially when undertaking rehabilitation of the worn anterior maxillary dentition. Figure 2 provides an extra-oral view of the case seen in Figure 1, where the discrepancy in the smile arc becomes evident.

The dental midlines

Ideally the dental midline should coincide with the facial midline. The maxillary centre line is best evaluated against the midpoint of the philtrum; a discrepancy of up to 2 mm between the maxillary midline and facial midline may be considered as being aesthetically acceptable. The mandibular midline should ideally be coincident with the maxillary midline; however, this is not always seen physiologically (as discussed later in this article).

Tooth colour

Teeth should be evaluated for variations in colour, hence:

- Hue – basic colour,
- Chroma – saturation of the basic colour,
- Value – brightness.

Tooth form

The form of the maxillary central incisors (ovoid, square or triangular) has been suggested (without any scientific basis) to

reflect on the personality, sex, age, and strength index of a particular individual. Tooth form may also alter with age as a result of tooth wear. In the absence of any information relating to the likely morphology of the anterior teeth before ascertaining wear, the use of such information may help determine an appropriate tooth form.

Tooth size, proportion, shape, and symmetry, position & axial inclination

Tooth proportion, shape & size

The maxillary central incisor teeth are generally accepted as most dominant teeth in the aesthetic zone, with reported average lengths and widths of between 10 and 11 mm and 8 to 9 mm, respectively;¹⁶ suggestive of height to base ratio of 1.2:1. Knowledge of these baseline values may help plan the restoration of the severely worn anterior dentition.

The concept of the Golden Proportion is a mathematical concept used by some practitioners. It suggests an ideal proportion of 1:1.618; thus, in the context of the anterior maxillary dentition, this would imply that the maxillary central incisor should be 1.618 times wider than the maxillary lateral incisor, which in turn would be 1.618 times wider than the maxillary canine when viewed from a frontal direction.¹⁷ The Golden Proportion, however, has been described to exist in less than 20% of all natural dentitions examined.¹⁸

The above concepts may be applied when designing a 'new aesthetic zone,' where the existing features may have become markedly affected by the process of tooth wear.

Contact areas and embrasures

As per the universally accepted concepts in dental aesthetics, embrasure spaces should ideally increase in size in progressing distally

away from the midline, while contact points should be positioned in a more apical location when moving distally from the midline in a symmetrical manner.

Gingival aesthetics

The gingival zeniths of the anterior maxillary segment should ideally be symmetrical about the midline, with the horizontal gingival levels of the central incisor and canine teeth being placed slightly more apical (by approximately 1 mm) than that of the lateral incisors.

Forming the aesthetic prescription for the tooth wear patient

In order to develop predictability with the establishment of the definitive aesthetic prescription, there is a need for a technique that permits the opportunity for all to reversibly visualise any planned aesthetic changes, gain informed consent and avoid unrealistic expectations. In practice, this is generally accomplished by the use of one of the following techniques:¹⁹

- The 'intra-oral mock-up' also referred to as, 'dry-and-try techniques,' or by the use of
- Digital smile evaluation.

The intra-oral mock-up technique

With this method, it is appropriate to commence with the selection of a suitable shade of resin composite. The anterior maxillary teeth should ideally be dry; no effort should be made to prepare the teeth for adhesive bonding.

Where an increase in the length of the central incisor teeth is desired, the width of the tooth should be determined using a suitable dental probe with millimetre markings. Resin composite is then applied to one of the air-dried maxillary central incisor teeth, aiming to attain a rough length to width ratio of 1.2:1. Accordingly, for an average width maxillary central incisor with a width of 8–9 mm, a length of 10–11 mm would be deemed suitable. The rest position of the upper lip should also be applied as a useful guide to determining a suitable length.¹⁵ Where a decrease in the length of the selected tooth is desired, a surgical marker pen can be used to mark the desired length to attain the above proportions.

The patient should then be requested to enunciate the letters 'F' or 'V,' with the operator concomitantly observing the relationship between the incisal edge and upper



Fig. 3 Completed intra-oral mock-up 'dry-and-trial' addition of un-bonded resin composite, using the universal concepts in dental aesthetics to build a bespoke aesthetic prescription

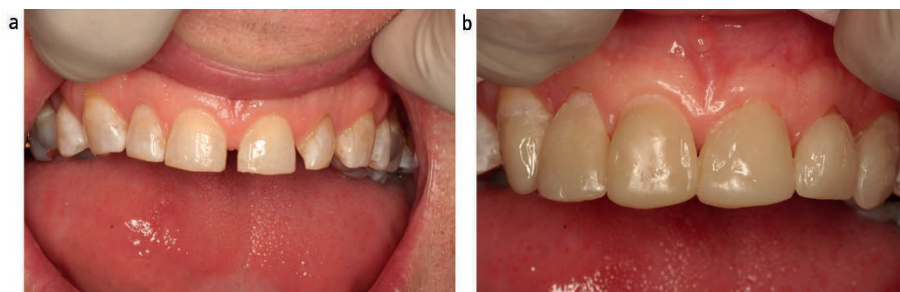


Fig. 4 (a) Pre-operative view of a patient with tooth wear, (b) Intra-oral mock of up the case seen in Figure 4a, by the addition of un-bonded resin composite to help prepare an appropriate functional-aesthetic wax-up

border of the lower lip. Ideally, the incisal edge should be contoured to follow the profile of the upper border of their lower lip, with a constant spatial distance of approximately 3 mm. Having re-established the relationship of the incisal edge to the 'smile arc' during a posed smile, this latter process is repeated at the contra-lateral tooth.

With the aid of a set of wooden spatulas, the relationship between the incisal edges of the maxillary anterior teeth and the inter-pupillary line should be determined. Ideally, parallelism should exist. Where the inter-pupillary line may be canted, an alternative reference plane such as the horizon should be used.

The profile of the maxillary incisor teeth should next be appraised in a lateral direction. Material should be added or removed so as to develop a lateral profile that presents itself with two or three planes on the labial (facial) surface and provide an appropriate level lip support attained.

Attention may now be focused onto contouring the mock-ups to crudely reflect the patient's age, sex, personality and strength index culminating in an ovoid, square, tapering

or square-tapering profile. Invariably, the latter will involve the adjustment of the mesial and distal incisal edges respectively. For cases where there may have been considerable loss of incisal edge tissue, thought should be given to the position of the contact area, which should be ideally positioned in the incisal third of the maxillary central incisor tooth, 6 mm coronal to the crestal bone so as to develop ultimate papillary infill and the elimination of unwanted excessive black spaces.²⁰

For cases where there is a need to alter the width of the maxillary central incisor teeth (such as in the case of diastema closure), resin composite may be added to the inter-proximal surface(s). The width to length ratio may be applied as discussed above. The relationship between the maxillary dental midline and the facial midline should also be appraised; ideally, the discrepancy should be no greater than 2 mm.²¹

Having formed the maxillary central incisor teeth to the desired morphology (or indeed where such teeth may be deemed to be aesthetically acceptable), attention is diverted towards the maxillary lateral incisor teeth. Resin may

be added in an analogous manner to the above to the incisal edge (assuming an alteration in the length is indicated) such that the incisal edge is placed approximately 2 mm apical to that of the central incisor, with an overarching aim of developing the profile of the incisal edge in accordance with the patient's smile arc. Thus, in going from the midline, the axial inclination of maxillary anterior teeth should assume a 'mesial tilt' and the mesial contact point should be placed slightly more apical to that formed between the central incisors.

For cases where an alteration in the width of the lateral incisor is desired, the concept of The Golden Proportion may be applied, as described above. The use of a Golden Proportion gauge (Golden Mean Gauge) may be helpful with this exercise. The profile of the contra-lateral maxillary lateral incisor should be developed to roughly mimic that of the above. The embrasure space formed between the central and lateral incisors, and indeed with that of the canine teeth should progressively increase in size in progressing distally from the midline.

Resin composite may now be added to the maxillary canine teeth, applying the concepts discussed above, with the aim of maintaining symmetry across the midline. The average length of a maxillary canine should be 11–13 mm.

Attention may now be diverted toward the development of the desired gingival aesthetics. Where there is a need to alter this, resin may be added to areas to simulate the effect of crown lengthening, such that the horizontal levels of the central incisor teeth and canines are in the same plane, with symmetry across the midline and approximately 1 mm apical to that of the lateral incisor. However, the subject of crown lengthening surgery is beyond the scope of this article.

At this stage, the width of the patient's smile should also be assessed. The presence of excessive black spaces between the cheeks and teeth (negative buccal corridor) may look particularly unaesthetic; thus, if required, resin may be added to the buccal cusp tips of the premolar teeth to assess the effect of reducing this dimension.

Finally, the mandibular teeth should be viewed in relation to the maxillary mock-up. Consideration may be given to the adding of resin to the mesial surfaces of the lower central incisors, with the aim of attaining a congruent vertical reference with the maxillary centre-line; although co-incidence of these planes



Fig. 5 (a) A set of accurate dental casts for the patient seen in Figures 4a and b, mounted in centric relation on a semi-adjustable articulator. (b) Completed functional-aesthetic wax-up, using the information following the mock-up shown in Figure 4b as well as the occlusal prescription, having decided to use direct resin composite to restore the aesthetic zone. This view shows the intercuspal position; material will be placed in 'supra-occlusion', using the Dahl Concept to provide care, (c) View of wax-up in protrusive excursion

has been reported to exist among 25% of the population only.²²

Phonetic tests can help in determining the height and bucco-palatal width of the anterior teeth. When the patient is asked to enunciate the 'F' sound (in English), typically by counting from 40 to 50 – if noisy and imprecise, this may be a sign of the need to shorten the length of the maxillary central incisors. In a similar manner, if the palatal surfaces have been over-bulked (which may limit freedom in centric and feel uncomfortable), this will not allow for the effective enunciation of the 'S sound' (in English), which may be elicited by asking the patient to count from 60 to 70.²³

Having completed the mock-up, it is appropriate to show the proposed changes to the patient using a hand mirror, as well as attaining high quality photographs of the mock-up, and to also considering a video recording to assess the effects of dynamic aspects, such as on the patient's speech. Adjustments can now be readily made as per the patient's desires and further to any dentist-patient discussions by simply adding or removing resin composite.

Once all parties are reasonably satisfied, an over impression of the mock-up using a suitable form of dental alginate or silicone putty should be taken before its removal.

The above records (including any further information such as occlusal records) should be dispatched to the laboratory with a detailed occlusal prescription, aesthetic prescription and the photographic records taken, so that an aesthetic and functional diagnostic wax-up may be formed by the dental technician.

Figures 3, 4a and 4b provides an example of an intra-oral mock-up, prepared in the manner described above. The latter case also requested the closure of the central diastema, and was approached using the techniques as described above.

Digital smile evaluation (DSE)

With advances in digital photography and information technology software, it has become possible to undertake the process of aesthetic design using universally accepted concepts in dental aesthetics, such as those relating to ratios, proportions, tooth position/alignment, shape/form and colour respectively.²³ The process of DSE requires taking an array of full face photographs using a high-resolution digital camera with a macro lens, followed by the use of a programmed 'digital ruler' to carry out assessments of the patient's aesthetic zone. It is beyond the scope of this article to provide a comprehensive account of the DSE. However, with the use of the available software tool, the clinician is able to display differing tooth proportions (which may be particularly helpful in the case of the worn dentition) and thereby:

- Simulate the effect of an altered pattern of tooth alignment
- Experiment with an array of available differing tooth forms (with the aim of harmonising with the patient's facial features using a library of available differing tooth forms
- Attempt to display the effect of changing parameters relating to tooth colour – the colour temperature, brightness, contrast and saturation respectively.

With these tools, together with input from the patient, the dentist is in a position to design the features of the aesthetic zone.

The above information can be used by the dental technician to prepare a diagnostic wax-up, with the added merit of the information being sent electronically, as well as to consider the use of CAD technology to fabricate a 'virtual wax-up'.

The preparation and evaluation of the diagnostic wax-up

Having determined the choice of restorative material(s), the dental technician will now be in a position to fabricate a diagnostic wax-up in an attempt to try and meet the aesthetic and functional demands of the patient. It is the dental technician who will form the mock-up on the dental casts, (that will usually require mounting on an appropriate form of dental articulator). The use of an Arcon type of semi-adjustable is generally considered acceptable.²⁴ Figure 5a demonstrates a set of dental casts for the case as seen by Figure 4 mounted in centric relation on a semi-adjustable articulator, upon which a functional-aesthetic wax-up will be prepared.

It is beyond the scope of this article to comprehensively appraise the precise nature of the functional-occlusal prescription, as well as to explore some of the controversies surrounding the depth of available evidence to support the concepts and protocols of traditional occlusal practice – as per the guidelines for good occlusal practice.^{25,26} However, in general, given the complex nature of the restorative treatments that are likely to be prescribed for the patient with tooth wear, it would be reasonable to provide evidence for the implementation of the guidelines for good occlusal practice and ultimately, in general, aim for an occlusal prescription that relates to the likely 'ideal occlusal scheme'.²⁷

From a pragmatic perspective, the concept of the mutually protected occlusal scheme (MPO)^{28,29} is frequently applied by many practitioners as the occlusal end-point (circumstances permitting) when considering restorative rehabilitation of the worn dentition. The presence of a canine-guided/canine-protected occlusion is also considered to be generally desirable (pending the good health of

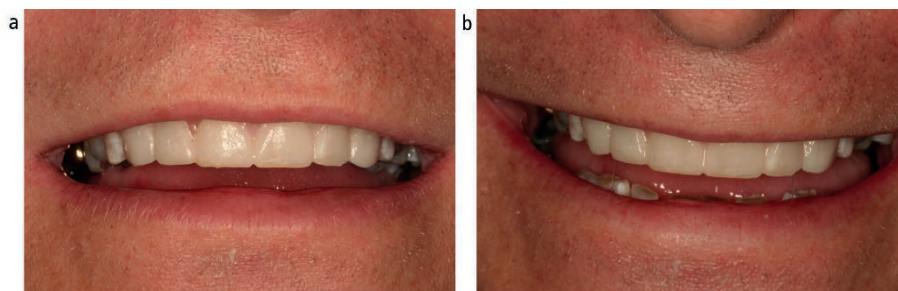


Fig. 6 (a) Intra-oral mock-up, using a provisional crown and bridge material into an impression of the wax-up (Figs 5b and c), with the patient making a broad smile. (b) Mock-up, with the patient making dynamic movements; smiling, phonation

the canine teeth).³⁰ This form of occlusal scheme is also relatively easier to accomplish from a technical/clinical perspective when undertaking restorative rehabilitation when compared with the scenario of mandibular guidance as being provided by a number of posterior teeth on the working side (group function).³⁰

As part of effective communication, it is imperative that the clinician provides the dental technician a clear and accurate occlusal prescription, together with any other relevant details as discussed above. Figures 5b and 5c show an example of a completed functional-aesthetic diagnostic wax-up. The wax-up as a stand-alone is of limited benefit in explaining the proposed changes. For this purpose, there is the need to apply a technique that allows the patient to visualise the proposed changes in their own mouth; this protocol is described later in this article.

Upon the receipt of a completed diagnostic wax-up, the latter should be carefully appraised. If satisfactory, an impression of the wax-up should be taken using a polyvinyl siloxane-based (PVS-based) material (or in the alternative, a vacuum formed matrix formed on a duplicated cast of the wax-up). The patient's teeth can then be lightly lubricated using petroleum jelly (concomitantly ensuring that any gross hard tissue undercuts are suitably blocked out) and the chosen shade of provisional crown and bridge resin placed into the impression/matrix, making sure to apply material that would crudely conform to the volume of wax used (avoiding the need to trim away excessive set resin). The impression/matrix is then carefully seated in the mouth; once set, the resin-based material can be carefully trimmed and any refinements take place. In some cases, however, there may be the occasional need to reduce some tooth tissue, during the management of the tooth wear, that may prevent a wax-up trial from being readily undertaken.

An alternative technique to the above, may include the fabrication of a 'clip-on smile' (formed by the dental laboratory – such as the Snap-on-Smile, by DenMat USA), or where CAD software may have been used, the digital design can be used to mill a model from which a silicone key can be made (DSD Connect, DSD Technology, Romania) and subsequently used to produce an intra-oral mock-up as described previously in this article.^{19,23}

The intra-oral mock-up derived using the wax-up (sometimes referred to as the 'trial-smile') should be critically appraised, inclusive of the aesthetic, occlusal and phonetic features as described previously in this article. In some cases, there may be an indication for the wax-up to be corrected and the process repeated. The use of photographs and/or videos of the mock-up can prove of benefit not only to facilitate communication with the laboratory, but to also provide the patient with information that they can take away to make an informed decision about the proposed changes/plan of care, giving them the opportunity and time to discuss matters with their friends/family as well as with the dental operator.¹⁹

Figures 6a and 6b depict examples of an intra-oral mock-up, formed as described previously in this article, using the diagnostic wax-up as seen in Figures 5b and 5c.

Definitive restorative rehabilitation of the aesthetic zone

The use of direct materials

Having granted acceptance of the proposed treatment plan as well as the outcomes of the diagnostic stages as discussed above, the next stage would involve the transference of the diagnostic prescription to the provision of the definitive restorations.

While there is a lack of consensus with what may be the most appropriate dental material

for the rehabilitation of the wear patient, it has been agreed that care should commence with the implementation of effective counselling, monitoring and preventative management.³¹ Where the decision has been taken to proceed with active restorative intervention, valid informed consent must be attained, and treatment provided should, where possible, be of an 'additive' nature as opposed to 'subtractive' – so as to avoid the further undue loss of tooth tissue. Where feasible, a minimally invasive approach should be adopted over the use of more traditional indirect techniques.³¹

Accordingly, the use of resin composite when applied directly can provide an appropriate option for choice for the rehabilitation of the anterior aesthetic zone (where the conditions are conducive towards effective adhesive bonding).³¹ Resin composites used in this manner can offer the potential for achieving an acceptable aesthetic outcome with minimal intervention, bestowing the additional merits of the ease of adjustment and repair (as well as substitution with other materials), the avoidance of further laboratory stages and costs, being minimally abrasive towards the antagonistic surfaces and the scope to apply the restorations within a single appointment.^{32,33} Figures 7, 8, and 9a–c, show examples of patients with anterior maxillary tooth wear managed by the addition of direct resin composite.

The clinical techniques used to apply direct resin composite to the worn dentition

In general, the techniques required to directly transfer the information from the diagnostic wax-up to the worn dentition may involve the use of either;³³

- A customised polyvinylsiloxane (PVS) matrix (commonly referred to as a silicone key,³⁴ or
- A customised vacuum formed matrix.^{33,35–37}

While the effective application of the PVS matrix can assist with the layered placement of resin composite, allowing not only the effective curing of carefully controlled increments as well as the development of anatomical form and colour by the use of differing shades and opacities of resin, the use of the vacuum formed matrix is associated with some well documented complications.³⁷ Notably, the risks associated with the latter include; the over-loading of the matrix, air entrapment as well as technical complications around the management of the inter-proximal area.

More recently however, a protocol involving the use of a modified/customised vacuum formed matrix to permit the insertion of pre-warmed resin composite has been described by Mehta *et al.* (termed the 'injection moulding technique').³⁷ This aims to overcome some of the latter risks with the use of an unmodified vacuum formed matrix. The latter may prove beneficial for the managing of the worn mandibular anterior dentition.

A number of studies have evaluated the efficacy of resin composite to treat wear of the anterior dentition in the short to medium term (2 to 5 years). Survival rates at or about the value of 90% have been described;³⁸⁻⁴¹ in some cases inclusive of the placement of restorations in the supra-occlusal position, using the concept of the Dahl Phenomenon/Relative-Axial Movement.⁴²⁻⁴⁴ However, caution needs to be applied when making comparisons between the aforementioned studies due to the small sample sizes (in some of the studies), as well as the diversity in the restorative and investigatory protocols between them.⁴⁵

Nevertheless, it would appear that in the short to medium term, mechanical failure (including complete bulk fracture, marginal fracture, the gradual attrition of the applied material and loss of surface detail/contour of the applied restorations as well as the chipping of material) can be concerns with the use of this material when placed directly.³⁰ Selection of an appropriate form of material, the thickness of the material applied, as well as the filler volume may be important factors to consider in attempting to enhance the longevity of the restoration placed.⁴⁶ Micro-filled resin preparations are perhaps better avoided when managing tooth surfaces where occlusal loading is likely to be encountered.

In relation to the medium- to longer-term studies documenting the survival of direct anterior resin restorations to treat tooth wear, the published data is somewhat more diverse. Milosevic and Burnside,⁴⁷ as part of 8-year prospective study, reported an overall failure rate of 7% among a sample of 1,010 restorations, with a mean follow up time of 33.8 months. Failures were defined by the presence of a total debond or material chipping; the importance of appropriate posterior support was emphasised in this study.

In contrast, the data presented by Gulamali *et al.*,⁴⁸ has indicated less favourable outcomes, with a median survival time for 283 restorations at a 10-year follow up of 5.8 years, with 90% of the restorations showing signs of major and minor failure due to factors such as wear,



Fig. 7 Restoration of the aesthetic zone of the case seen by Figure 1, using directly bonded resin composite to copy the established functional-aesthetic prescription at a 2-year review



Fig. 8 Restoration of the aesthetic zone of the case seen by Figure 4, using directly bonded resin composite to copy the established functional-aesthetic prescription images shows restorations in a protrusive excursive position at 5-year review

marginal discolouration and/or fracture. Analogously, Bartlett and Varma, among their sample of 251 restorations placed between 2012 and 2016, reported a success rate of 83%, with failures primarily due to chipping or bulk fracture; 63% of the patients included showed the presence of at least one fracture.⁴⁹ It was suggested that operator skill and the aetiology of the condition may have an influential role on the level of success that can be expected.

Long-term data is unfortunately very much lacking. One study comparing the survival of direct and indirect restorations for the treatment of advanced tooth wear over the course of a 10-year assessment period reported

a survival rate of 62.0% was reported for direct resin-bonded composite restorations and 74.5% for indirect conventionally retained restorations respectively. Bulk fracture was noted as the most common mode of failure for the former, which were readily addressed conservatively by either repair or replacement. In contrast, failures of the indirect variety of restorations were generally of a catastrophic nature, frequently involving complete loss of restorations, which often necessitated subsequent endodontic treatment or a dental extraction. Interestingly, a promising survival rate of 78% was described for directly bonded resin composites placed in the anterior region.⁵⁰

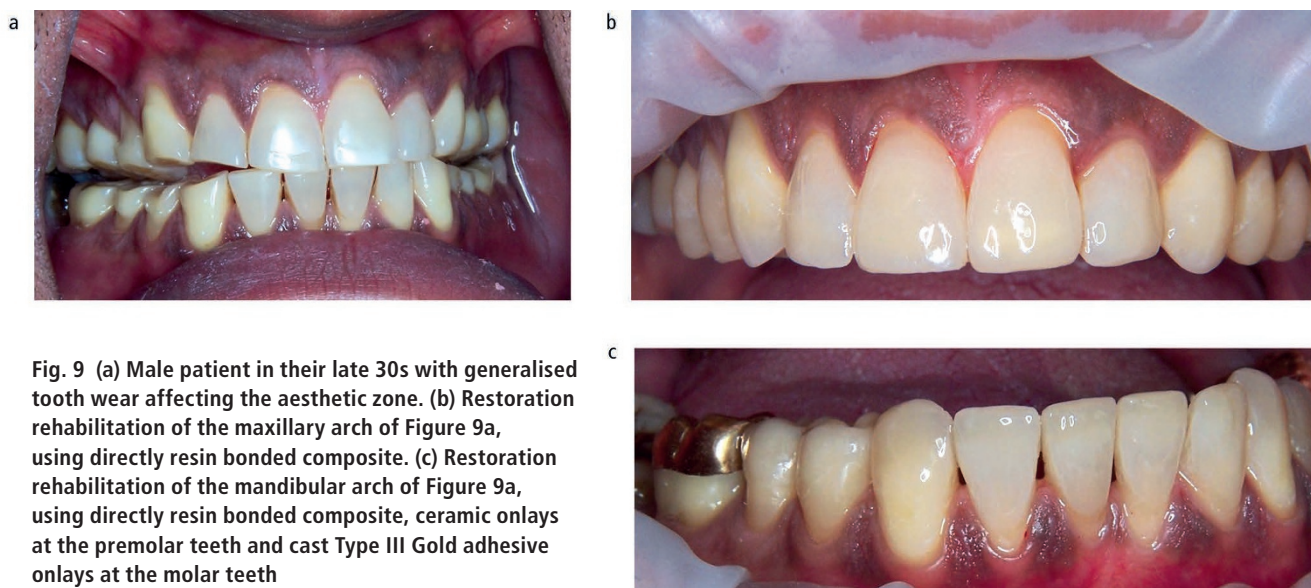


Fig. 9 (a) Male patient in their late 30s with generalised tooth wear affecting the aesthetic zone. (b) Restoration rehabilitation of the maxillary arch of Figure 9a, using directly resin bonded composite. (c) Restoration rehabilitation of the mandibular arch of Figure 9a, using directly resin bonded composite, ceramic onlays at the premolar teeth and cast Type III Gold adhesive onlays at the molar teeth

In conclusion, there appears to be some evidence to support the role of direct resin restorations for the medium-term management of tooth wear in the aesthetic zone; especially given the financial merits, allowance of restoration replacement without significant complication and the preservation of tooth tissue that an additive technique using this material has to offer. Such restorations may also serve a 'diagnostic purpose' in allowing the patient to 'test-drive' the functional-aesthetic prescription, which may be substituted for alternative dental materials at a later point in time, as discussed later. However, patients must be advised of the potential regular need for polishing, repair and occasional replacement when prescribing direct resin composites for the treatment of anterior tooth wear.³³

The use of indirect techniques and materials

Indirect restorations may be fabricated in the dental laboratory to mimic the accepted functional-aesthetic prescription, as discussed above. A variety of tooth-coloured materials may be used to restore an aesthetic zone affected by the process of tooth wear.

The use of indirect composite resin restorations should be discussed as part of the process of attempting to gain valid informed consent.³¹ Indirect resin restorations when compared to the use of direct techniques used for the management of cases of tooth wear offer the merits of improved control over occlusal contour and vertical dimension; as well as the possibility of reduced chairside time and superior wear resistance respectively. However, at times, the

aesthetic outcome and marginal adaptation can be inferior to the use of ceramic materials, with restorations sometimes appearing bulbous and the added drawbacks of the incurrance of laboratory fees, as well as the potential for wear and leakage of the resin-based luting agent used to retain the restorations *in situ*.^{32,33}

While there is some evidence to support the successful role of restorations fabricated in this manner for the restoration for anterior tooth wear,^{40,51} the overall level of available evidence for the success and/or survival of indirect restorations is generally lacking (when compared to that for direct materials/restorations).

Satterthwaite has described an interesting approach combining the use of indirect and direct resin composite restorations, whereby the palatal aspect of the restoration can be formed indirectly, and the labial portion developed directly following the cementation of the indirect palatal composite veneers.⁵²

With advances in digital dentistry, the use of CAD-CAM manufactured restorations using high-density polymeric materials may permit the use of more robust materials that may be applied in thinner sections than dental ceramic, as described by a set of case reports presented by Edelhoff *et al.*⁵³

Adhesive ceramic restorations can also be used for the treatment of the aesthetic zone affected by the process of tooth wear.^{54,55} Restorations may take the form of bonded veneer restorations to those of all ceramic crowns. Ceramic restorations in general can offer superior levels of marginal adaptation, wear resistance and aesthetics in relation to resin composite. However, their brittle nature and

the susceptibility of ceramic towards chipping and fracture (especially in thinner sections), together with the difficulty with adjustment and repair are established concerns.^{32,33}

Milosevic reported a relatively low failure rate of 15.5% of over a median follow-up period of 72 months among a sample of 161 zirconia crowns used to restore severe anterior tooth wear; failures were attributable to total debond or to minor delamination chips within the ceramic layer.⁵⁶ The presence of an edge-to-edge incisor relationship, as well as an underlying tendency towards developing tooth wear as a result of attrition or bruxism was also linked to a higher risk of failure.

Increased treatment cost may also be a concern with the use of adhesive ceramic restorations – especially if the patient fails to accept and adapt/accept the functional and/or aesthetic rehabilitation provided.³³ However, the use of adhesive ceramics may be considered suitable among cases that may have been successfully stabilised using direct resin composites. Indeed, in 2007, Magne *et al.* described an ultra-conservative approach for the management of worn palatal surfaces with the use of occlusal therapy combining centric relation and the use of the Dahl Concept.⁵⁷

Finally, in relation to the predictable use of traditional, conventionally-retained crown and overlay/onlay restorations, such forms of dental restoration may be indicated among patients where the placement of adhesively-retained restorations may not be achievable (as in the case of the presence of multiple units of existing, failed anterior crown restorations) or where the impact of the maintenance elements associated

with the placement of direct resin composite restorations may be of significant concern to the patient.³³ Under such circumstances, having gained informed consent including a clear appraisal of the known associated risks (often referred to as 'biological complications', such as the loss of coronal volume and pulp tissue trauma),^{58,59} predictable outcomes can be achieved by the fabrication of laboratory made 'custom indirect provisional crowns' as per the diagnostic functional-aesthetic prescription attained as described previously in this article.

Provisional restorations should be tried-in and adjusted as necessary, either by subtraction or the addition of direct resin composite, until the appropriate occlusal contacts and aesthetics are developed. The restorations should then be cemented in by using a temporary cement. The patient should be periodically reviewed for tolerance and adaptation.

Following an observation period of approximately 6 to 8 weeks, with the patient reporting the lack of any symptoms and signs that may help to suggest the attainment of a functionally and aesthetically acceptable outcome, the features of provisional restorations may be copied using a conformative approach, employing the use of a customised incisal guidance table to copy the dynamic occlusal prescription as established by the process of using the provisional restorations.²⁷

When prescribing ceramic-based restorations, the latter may be tried at the bisque stage to permit adjustments before the final glazing process. Following the process of glazing, the definitive ceramic restorations may then be cemented initially using a temporary cement to allow for a further period of appraisal.

Summary and conclusions

The successful management of the dentate patient presenting with tooth wear affecting the aesthetic zone can prove to be an arduous process. However, with the establishment of an appropriate diagnosis coupled with careful planning, a sound background knowledge of some of the key concepts in restorative dentistry, and followed up with a good standard of technical execution of the treatment plan, a predictable outcome can be achieved.

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