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It fits too well
The modern problems with CAD/CAM technology and resin bonded bridgework – A case study

Aims and Objectives:
Principle 7 **Maintain, develop and work within your professional knowledge and skills**

- Educational aims:
  - to highlight the use of CAD/CAM technology within the dental profession
  - to inform the reader of potential aesthetic issues within too good a fit for a resin bonded bridgework
- CPD outcomes:
  - to highlight how CAD/CAM technology has developed within the dental workforce and issues that may arise during fabrication
  - to highlight satisfactory film thickness of luting agents for longevity and aesthetics for restorations

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PEER REVIEWED

Abstract

Dentistry is currently undergoing a digital revolution. Computer aided design/computer aided manufacturing (CAD/CAM) has been introduced for the construction of crowns and bridges as an alternative to the lost wax technique. The precision of CAD/CAM to produce a restoration with a predetermined internal space is crucial to allow enough room for the luting agent. Recently, luting agents have been developing rapidly, aiming to achieve minimal film thickness while possessing the low solubility and high strength necessary for long-term retention and longevity of the restoration.

The aim of this article is to describe a CAD/CAM constructed resin retained bridge that fits too well, highlighting the reason for it failing to achieve its aesthetic goal.

Introduction

In the last 20 years, dental technology along with medical and information technology has changed the way we interact with computers in all industries. In the past there was only one way to make indirect dental restorations, getting on some gloves (maybe not always 20 years ago!) and getting a patient covered in impression material. This has now changed. You can get the information from the mouth via a scan, send the information and receive your restoration.

There are multiple combinations of information acquisition available. The common methods for producing indirect restorations still regularly involve classical impressions, as intraoral scanners are expensive commodities. After impressions or scanning, conventional laboratory fabrication or dental CAD/CAM (computer aided design, computer aided manufacturing) is used, as shown in *Figure 1 (overleaf)*.

The conventional laboratory process
Following the preparation of the abutment/s, a silicon impression is obtained. A stone model is prepared at the laboratory as a replica. Wax patterns are then manually fabricated for metallic restorations, followed by the precision casting and porcelain veneering if required. The conventional powder build-up firing process of porcelain is still technically sensitive.

The dental CAD/CAM process

With the fourth generation CAD/CAMs available, the prepared abutment is scanned by an intraoral digitiser to obtain an optical impression. This image is recognised on the monitor and transferred to a 3-D graph using CAD software. Finally, the restoration is processed by a computer assisted milling machine (CAM).

When considering the difference in the steps above, one can conclude that conventional methods of laboratory-fabricated prostheses are labour-intensive and require high skill and precision. Using CAD/CAM it seems can save time and

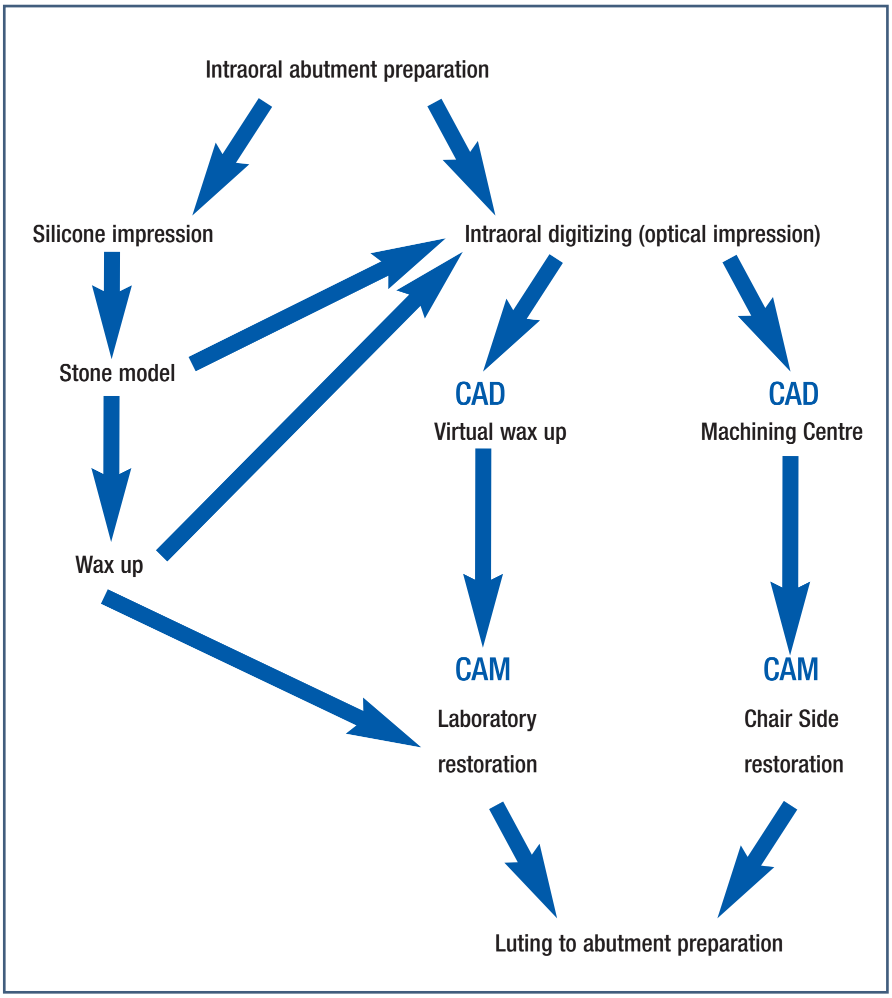

Fig.1:

resources, again as long as you are computer savvy, as CAD/CAM technology can compensate for changes in dimension (possible shrinkage) that come with processing. CAD/CAM can allow for easier quality control checks by designing optimal shapes, which can be replicated based on material characteristics and thereby preventing degradations such as residual strain because of processing.[1] Another perk of digitising information is that optical impressions, processing data and final production plans can be saved to enable retrievability of information and quality monitoring of prosthetic devices constructed via CAD/CAM technology.

CAD/CAM

In the early 1970s, Francois Duret pioneered the dental CAD/CAM in restorative dentistry.[2] These systems have been used for the fabrication of fixed prosthetic restorations such as crowns, bridges, inlays, onlays and veneers.

CAD/CAM systems have evolved over the last decade and are now also used for the manufacturing of implant-supported prostheses, such as customised implant abutments[3] and diagnostic templates for implants.[4]

Materials used for CAD/CAM processing

In the early 1980s, nickel-chromium alloys were used as an alternative to gold alloys due to the increase in gold prices at that time. However, nickel allergies became a problem and a transition to allergy-free titanium was introduced.[5] Currently, the following materials are available for CAD/CAM processing:

- Metals, such as titanium, titanium alloys and chrome cobalt, have been processed using dental CAD/CAM milling devices.
- Ceramics, such as silica-based ceramics, infiltration ceramics and oxide high performance ceramics. Examples of the oxide high performance ceramics offered as blocks for CAD/CAM technology are aluminium oxide and zirconium oxide, with the latter having high flexural strength and fracture toughness compared with other dental ceramics, increasing the longevity of these restorations.[6]
- Resin materials, either to be used for the lost wax technique, or for long-term temporary restorations.

Along with increased adoption of technology, patients are demanding more conservative management of their teeth and tooth replacement. This has led to the adoption of dental implants and resin based technologies to replace teeth without a removable prosthesis.

Resin retained bridges (RRBs)

RRBs were first developed as a conservative fixed prosthesis to replace missing anterior teeth. In 1973, Rochette described a perforated cast retainer that was considered a temporary restoration with two years of service.[7] Later, several studies concluded that unperforated retainers perform better than perforated ones.[8-10] Since then, however, there have been significant changes in materials used, design, tooth preparation and methods of construction of RRB's framework. Metal-free restorative alternatives are currently available, including fibre-reinforced composite resin and all-ceramic materials. These metal-free bridges are superior in aesthetics but metal ceramics have the following advantages[11]:

- Long-term clinical data available
- Most minimally invasive
- Relatively lower cost
- Simple rebonding
- Reduced connector fracture and better longevity of restoration

Poor results have been reported in studies where high gold alloys were used

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Table 1: Common reasons for failure of metal-framed resin retained bridges

Debond	One or more of the adhesive retainers became detached
Delamination or porcelain fracture	Ceramic-metal bond failure or fracture of a unit which necessitates a repair or remaking of the prosthesis
Caries	Requiring treatment under or immediately adjacent to a retainer
Fractured metal framework	Structural failure of the metal framework leading to implications for the survival of the restoration
Others	Periodontal loss of an abutment Patient's request – poor aesthetics Development of a pontic residual ridge discrepancy

in the construction of RRB retainers.[12] Nickel-chromium alloys were used almost exclusively because of their rigidity in thin section, and also the bond with resin was reliable. A study testing bond strengths of maxillary anterior base metal resin bonded retainers with different thicknesses found that the dislodging forces for the canine morphotype appeared to progress linearly with increasing thickness, and that a retainer of less than 0.7 mm thickness on a canine has been shown to have less resistance to dislodgement.[13]

Many factors affect the success of RRBs, including general factors such as patient age, health and expectation, and local factors related to dental health, RRB design, retainer coverage, luting resin and opposing dentition. Reasons for failure of a metal-framed RRB are described in *Table 1*.

Table 1: Common reasons for failure of metal-framed resin retained bridges

Debonding has been described to be the most common problem for metal-framed restorations (92.6% of all failures).[10] A study evaluating different fracture sites showed that 57% of the dislodgements were due to failure at the resin/retainer interface[14]; therefore, it is crucial to ensure perfect adaptation of the retainer to the abutment tooth. The following case describes the fit of a CAD/CAM constructed resin retained bridge that fits too well, highlighting the reason for it failing to achieve its aesthetic goal.

Case study

A 17-year-old male, JB presented at the orthodontics department for restorative options to replace his congenitally missing upper lateral incisors. The patient was fit and well and all extra-oral and intra-oral tissues healthy. A combined orthodontic/restorative assessment was conducted to examine the occlusion, positioning of facial support, tooth, gingival and smile line.

Treatment options available, considering level of destructiveness were:

- removable partial prosthesis
- resin retained bridges
- conventional cantilever bridges
- dental implant crowns/bridge

Treatment plan

The final agreed restoration was a double abutted resin retained bridge supported by UR1 UL1 to replace UR2 UL2 as one whole unit. This design allows for retention of the UR1 UL1 following orthodontics and takes into consideration the de-rotation and movement of the UR13 UL13 and their chance of relapse (*Image 1*).

No preparation of the teeth is required. After discussing a diagnostic wax-up with the patient, and agreeing the correct shade, a silicon impression was taken and sent to the laboratory. This impression was cast and the technician established an optical impression of the model. The digital model can be used with CAD/CAM to fabricate the metal framework. Aiming for the best possible fit, the software automatically attempts to achieve the closest fit (*Image 2 – overleaf*).

On the cementation appointment, the bridge was tried-in to confirm the accurate fit. Panavia™F opaque (Kurary, America, NY) was used, a version of the Panavia™ family, dual cured, fluoride releasing aesthetic universal resin based cement. The patient was happy on leaving the surgery.

The patient returned two weeks later as he had noticed that the front teeth appeared greyer than the surrounding dentition. It appeared that the metal of the bridge was showing through as a grey discolouration on the incisal edges of the central incisors (*Image 3 – overleaf*). Since the invention of opaque Panavia™, we no longer had any issues with metal shine through using this style of restoration. Therefore, we investigated what the differences were in this case causing metal to shine through.

The patient did have a higher level of translucency on the incisal edges of UR1 and UL1 with deep palatal cingulum. This means these teeth could more easily show decolouration, but again following normal protocol using opaque cement, this would not usually be an issue.

As the frame was constructed using CAD/CAM software (Renishaw DS20 White light scanner), we could recall all

Image 1: Metal framework for resin retained bridge

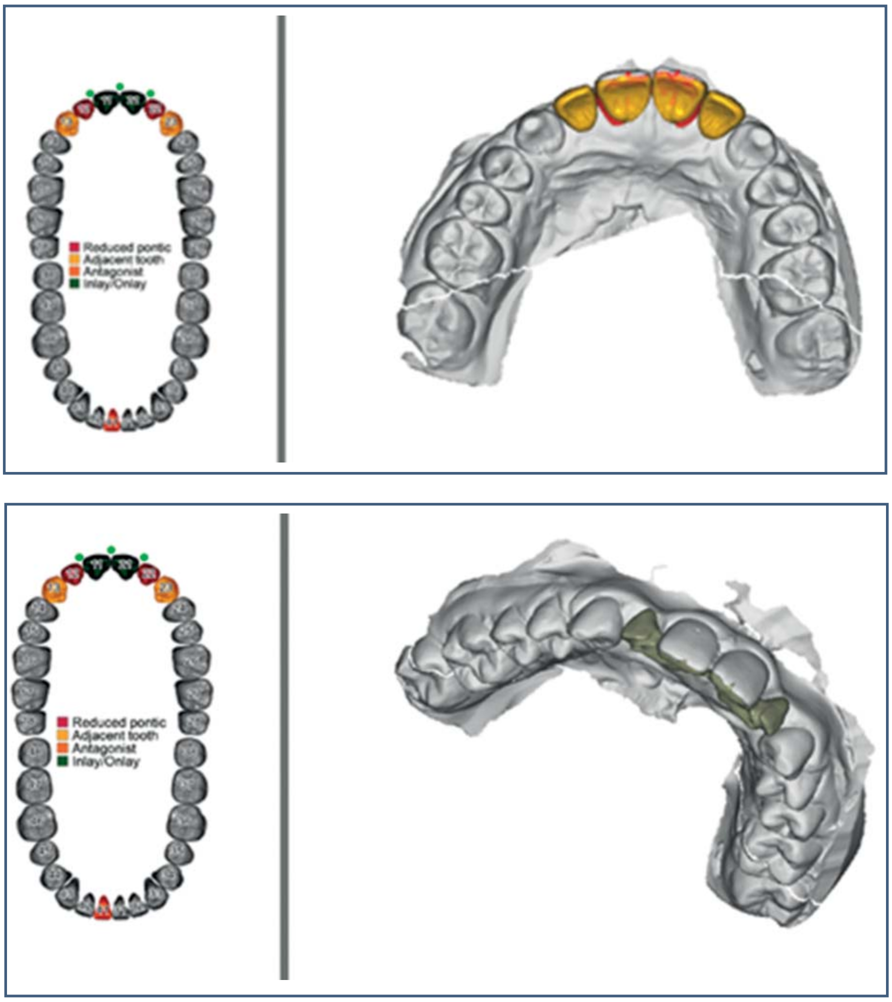

Image 2: CAD/CAM screen shot of the resin retained bridge

the settings and specification of the framework. On closer investigation the perfect fit that the CAD/CAM allowed for was '0 µm' space between the retainer and the abutment teeth in order to achieve the perfect fit. However, this automatic setting was not what the dentist prescription or a technician would see as a perfect fit because it was not allowing any space for cement. This space for cement normally occurs naturally due to small errors is manufacturing by hand.

Therefore, due to the accuracy of CAD/CAM, there was insufficient space for cement. This meant that even with opaque cement, the film of cement was too thin, allowing the metal retainer to show through the translucent incisal edges. Despite the retainers having a 'perfect' fit, luting agents must maintain a minimal film thickness necessary for long-term retention of the restoration and sufficient opacity. Therefore, the setting on the CAD/CAM software was intentionally changed to accommodate enough space for the luting agents. A new RRB was constructed via CAD/CAM with a space of '30 µm' between the tooth and retainer to allow enough thickness for the cement.

The new RRB was cemented using the same cement. A difference was noted aesthetically as no metal was showing through the incisal edges of the central incisors (*Image 4*).

Discussion

Location and fit of any metal framework has a high clinical relevance and is important to biological and mechanical restorative failure. The so-called 'clinically acceptable' marginal fit has varied in the literature, with previous investigators considering the marginal discrepancy of less than 50 µm to be acceptable and is difficult to detect under clinical conditions.[15] The closer the framework of the retainer and the margins to the abutment tooth structure, the smaller the gap and thickness of the exposed luting cement layer. Nevertheless, a large space favours cement degradation, which could be described by dissolution, mechanical wear and erosion.[16] Jacobs and Windeler found no significant difference in the rate of cement dissolution for gaps ranging between 25 and 75 µm, whereas a gap size of around 150 µm demonstrated a statistically significant increased rate.[17]

On the other hand, a framework that fits too well with no space for the cement, will also lead to debonding and failure of the restoration.

The film thickness of a luting material is influenced by several factors, including the size and shape of the filler particles, the substrate that the material will bond to, the viscosity of the mixed unset material and its setting time. In the past, composite resin cements have demonstrated a greater film thickness than other types of cements.[18] They set rapidly before they can flow to achieve their minimal film thickness goal. Resin based cements with high filler content will possess lower shrinkage on polymerisation and improved physical properties will increase the viscosity and diminish the flow.

Recent composite resin cements have improved their physical properties, aiming to achieve higher bond strengths, lower polymerisation shrinkage, and the improved colour stability Panavia™F cement used in this case has a recommended film thickness of 12 µm, which achieves a balance between optimal physical properties and minimal film thickness.

During the virtual 3-dimensional (3D) design of any restoration, CAD/CAM system settings allow the adjustment of different parameters, such as the cement space and restoration thickness.

Image 3: Grey area of the bridge

Nevertheless, research has shown that after milling is completed, manual adjustments of the CAD/CAM restoration by dental technicians could have a significant effect on improving the restoration fit.[19–20] In a mathematical study by Grajower and Lewinstein, it was suggested that the cement space for a crown could be set to at least 50 µm, of which 30 µm is utilised for the cement film and surface roughness, and 20 µm for distortions of the die or of the wax pattern.[21] As there is no tooth reduction required for the RRB in this study, the authors chose to set the CAD/CAM software to allow for up to 30 µm space for the resin based Panavia™F cement, which improved the opacity of the cement and prevented the metal shade showing through the incisal edges of the upper central incisors.

Conclusion

The evolution of computer aided design/computer aided manufacturing (CAD/CAM) technology in recent years and its advantages over conventional laboratory methods in the field of crown and bridge fabrication has led to an increased reliance on this technology. It is essential to plan the treatment and liaise with the laboratory to set the CAD/CAM software at the correct parameter in order to achieve a satisfactory film thickness of the luting agent that would provide longevity and aesthetics to the restoration.

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Image 4: Final bridge

It fits too well – the modern problems with CAD/CAM technology and resin bonded bridgework: A case study. Materials and equipment CPD – 60 minutes

To complete your CPD, store your records and print a certificate, please visit **www.dta-uk.org** and log in using your member details.

Q1 In terms of retainer thickness, what dimensions have been shown to be less resistant to dislodgement?
- **A** < 0.7 mm
- **B** < 0.9 mm
- **C** > 0.6 mm
- **D** > 0.9 mm

Q2 Debonding of metal-framed work restorations is a common problem. What percentage does the author highlight from the study of Dummer and Gidden (1990)?
- **A** 92.3%
- **B** 92.4%
- **C** 92.5%
- **D** 92.6%

Q3 In relation to fit, what was the dimensional space between the retainer and the tooth to allow for cement?
- **A** 25 µm
- **B** 30 µm
- **C** 35 µm
- **D** 40 µm

Q4 The film thickness of the luting material can be influenced by a number of factors. They are:
- **A** The viscosity of the unset material and its setting time
- **B** Dimension of the filler particles (size, shape, etc.)
- **C** The substrate that the materials will bond to
- **D** All of the factors mentioned above

Q5 During the early 1980s, what alternative alloy was used instead of gold?
- **A** Chrome cobalt
- **B** Titanium
- **C** Nickel-chromium alloy
- **D** Titanium alloy

Q6 The authors highlight a 'clinically acceptable' marginal fit from the literature. What was this value?
- **A** < 50 µm
- **B** < 60 µm
- **C** > 50 µm
- **D** > 60 µm

Q7 Rochette highlighted a perforated cast retainer for a temporary restoration. What was the service life?
- **A** 6 months
- **B** 1 year
- **C** 1 year 6 months
- **D** 2 years

Q8 Within the case study, what was the patient having replaced?
- **A** Upper lateral incisors
- **B** Upper incisors
- **C** Left lateral incisor
- **D** Right lateral incisor

Q9 What specific cement was used for the bridge?
- **A** Panavia™
- **B** Panivia™ F
- **C** Panavia™ F
- **D** Panivia™

Q10 A common factor for a failure of a metal-framed resin retained bridge is:
- **A** Delamination or porcelain fracture
- **B** Cement debond
- **C** Caries
- **D** All of the above

materials and equipment CPD 60 minutes