Restoration of Broken Down Teeth

Coursebook to accompany the hands-on course

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Tutors:

Professor Brian Millar BDS, PhD, FDSRCS, FHEA, FDT
Consultant in Restorative Dentistry, KCL
Specialist in Prosthodontics and Restorative Dentistry
Programme Director for Blended Learning MClinDent Prosthodontics Programme
Former Director of MSc Aesthetic Dentistry Programme
Private Specialist Practitioner

Dr Fariha Hussain BChD, MClinDent, PGCE
Clinical Senior Lecturer, KCL
Deputy Programme Director for MClinDent Fixed & Removable Prosthodontics
Private Practitioner

Course Description:

This course covers the management of all teeth damaged by trauma, caries, wear and cracked tooth syndrome. It will cover diagnosis and assessment of options through to management. Techniques for intervention utilise a range of materials to replace missing tooth tissue, including the use of adhesive materials as well as traditional methods. Replacement of missing teeth is discussed. Hands-on sessions include looking at suitable tooth preparation, the use of posts and cores, dentine replacement materials, the use of adhesive bridges, direct and indirect composites.

Aims:
To teach advanced practical techniques to restore aesthetics, function and the occlusion on broken down teeth using conventional and contemporary indirect restorations.

Objectives:

At the end of the course delegates will be able to:

- Select a suitable indirect material and tooth preparation including margin type and position
- Prepare teeth accurately and quickly
- Carry out predictable impressions
- Place effective provisional restorations
- Understand cementation protocols for different materials
- Restore aesthetics and function understand the destination driven approach
- Manage subgingival margins

Learning objectives:

- Know when to use indirect materials to restore root filled and broken down teeth
- Be able to use aesthetic and functional indirect restorations
- Know which materials and techniques to select for a given clinical situation
- Be able to design and make suitable provisional restorations
- Be able to take good impressions in difficult situations
- Understand and use the destination driven approach to tooth preparation

Tooth Assessment:

Broken down teeth can be assessed individually to reach a decision to save or extract. This decision is based on:

- Periodontal status
- Endodontic status
- Restorability
- Cost
- Prognosis
- Other factors including the opinion of the clinician and patient

There are no easy to follow guidelines in many cases.

Having a good quality recent peri-apical radiograph will be a help.

A good starting point is that the tooth needs to pass the perio, endo and restorability criteria.

If it fails one of these then extraction is indicated.

Some teeth may be more strategic due to the position in the mouth.

Restorative Options in general terms:

1. Direct Composite Resin is often ideal for damaged teeth eg tooth wear
Don't cut if possible. Reduce surface enamel only and bond composite to reshape teeth. Do a mock-up first "dry-it-and see" to check contour, patient agreement and shade. A putty index of this can be made to make final restoration easier.

2. Semi-Direct Composite Resin
Use preformed enamel shells such as *Componeer* (Coltene) which have the advantage of low cost, easy to adjust and high polishability. Technique is simple but consider doing first case on a model:

1. Select enamel shade (universal, white or bleached white)
2. Select size (5 options)
3. Try-in and select underlying shade which can be any material, any colour, enamel or dentine
4. Etch, bond, apply the underlying composite then place *Componeer* shell on top
5. Check alignment carefully
6. Remove excess composite around margins
7. Recheck position and margins
8. Light cure
9. Polish if necessary. Can characterise.

3. Indirect veneers/crowns
This is often the preferred option for broken down teeth. A broad range of tooth preparations will be looked at on the face to face day.

Many posterior teeth that are fairly intact but root filled will benefit from an overlay. This protects the tooth from occlusal forces yet is minimally destructive.

The overlay can be extended over the buccal surface to provide a more aesthetic restoration often called a Vonlay or Veneerlay.

Broken down teeth are more likely to require a core and full coverage crown. We will discuss all types including the aesthetic minimally invasive Vertiprep.

Techniques with adhesive composite:

Direct composite

Dry-it-and-see (old composite or *Revotek*, *GC*)

Smile Design principles: length, width, position, contour, symmetry

Determine the new incisal edge position

Check occlusion, function, phonetics

Can you copy the old restoration with an index? Putty or clear silicone (eg Elite HD glass)
Shade – 2 layers usually, trial cure to check colours
Trial restoration for contour and indices?
Determine line angle position
Isolation, matrix system (PTFE, Sectional?)
Clean surface with bur or sandblaster the etch eg 3 stage phosphoric acid etch/prime/bond
Place composite without increments (dentine, special effects, enamel)
Create surface anatomy
Margins – knife edge works well
Finishing: primary anatomy at first visit: labial profile (3D), incisal length, occlusion.
At same or later visit secondary anatomy: surface detail and texture/lustre (see later section).

Clear post-op matrix for easy repairs, eg Elite Glass HD

Chairside Inlay technique

Cut a non-undercut cavity and take impression in alginate (or condensation cure or *Impregum*)
Pour at chairside, eg bite registration silicone
Make composite inlay/onlay on the silicone die. Use matrix if it helps.
Light cure in the silicone
Remove restoration from the silicone die, remove flash and tidy, add if necessary, eg to contact area
Repeat light cure from all sides, hold light close and generate heat it all helps maximise the polymerisation conversion
Check in the tooth
Modify as necessary
Cement into cavity as an indirect restoration

Indirect technique

Cut a non-undercut cavity
Take impression in heavy/light addition silicone (see below for impression techniques)
Prescribe for a lab-made composite restoration, eg *Gradia Lab*
Cement into cavity as an indirect restoration

For speedy complete cavity filling with 3 sec light cure consider bulk-fill dual-cure composite (eg *FillUp*, Coltene). Many bulk-fills on the market actually are only partial cavity fill, ie linings materials, eg SDR. *FillUp* is a complete cavity single fill, based on the successful *ParaCore* range, tested over 7 years.

Crowns - Choice of Restoration

Many clinicians and technicians are becoming increasingly concerned over the reports of corrosion and sensitivity that has been triggered in some patients because of the use of certain alloys. Soldered joints have long been been shown to be problematic regarding bio-compatability but now it is metals in general. Nowadays metal-free options are frequently used: pressed ceramics such as e.max, milled such as zirconia and there are now excellent indirect composite materials that can be milled eg CRIOS.

The decision is usually between:

- Longevity: FVC (gold) wins by far. The gold overlay is particularly effective.
- Metal-ceramic: best compromise between longevity and aesthetics
- Other metal-based systems, eg. Captek, Gramm GES crown, Ducera gold – less popular now
- All-Ceramic systems, eg. E.max (Ivoclar), Suprinity (Vita)
- Monolithic Zirconia for good strength, minimal invasive prep, moderate aesthetics
- Poly-Glasses, eg. Gradia-Lab, Crios, Lava Ultimate

Full gold/partial gold crowns/overlays: unbeatable longevity coupled with minimal preps and outstanding marginal fit. Can be used subgingivally and with any cement (0.3 chamfer margin or vertical margin (BOPT/vertiprep), 1-1.5 occlusal, 6^0 taper, optional grooves). Can be prepared with the horizontal or vertical margin techniques.

Metal-ceramic look good if prepped correctly (1.5mm labial, 2mm occlusal, anterior ceramic margin, option metal collar posteriorly, proximal wing). Note the options for the margin: aesthetic (a 1.0mm rounded chamfer with metal cut back) or functional (a 0.3mm chamfer allowing a metal collar).

GC Gradia is a light-cured indirect restoration with micro-fine ceramic/prepolymer filler with a urethane dimethacrylate matrix to produce a superior ceramic composite with exceptionally high strength, wear resistance and superior polishability. Gradia is biocompatible and kind to opposing teeth. Easy to use and cement. Useful for long-term provisionals an where adjustment is likely.

e.max is the latest Empress ceramic with a long history of success and great aesthetics, probably the best aesthetics of all current materials. Can be used alone (eg as a ceramic veneer – thin and weak), on zirconia or as a cadcam material. Highly recommended (1.2 margin, 2.0 occlusal/incisal reduction)

Monolithic Zirconia (MZC) eg Opalite, for good strength, minimal invasive prep (as FVC), moderate aesthetics (as only stained and glazed) but requires high level clinical skill: good planning (as removal very difficult), an excellent prep (as no tolerance), great margins (can be horizontal 0.3mm chamfer or BOPT/vertiprep), a good impression (as scanning a thin margin is difficult), skilful provisional and remember it cannot be adjusted chairside or in the mouth. Potentially damaging to opposing teeth and enamel as very hard.

Crios (Coltene: a high performance indirect composite for CAD-CAM use. Great aesthetics, more flexible than ceramic, easy to adjust, polish and repair, can finish to knife-edge for great margins. Wear rates more similar to natural teeth than other materials so good for the occlusion long-term.

Preparations

Good marginal fit of a restoration is of importance to the long-term health of the surrounding hard and soft tissues. Supragingival margins are preferred. However, there are instances when margins are subgingival: where caries, a fracture line or an existing restoration is subgingival. In these circumstances it is desirable to make the margin supragingival by the use of conventional surgery, laser or electrosurgery. Sometimes it is sufficient to make the margin more accessible by the application of retraction cord and solutions. A recent development is the vertical margin ("margin-less crown") Despite the modifications in materials and delivery methods, the impression recording technique remains important. Good soft tissue management is required to provide haemostasis and accessible margins and may include:

- Improving the oral hygiene beforehand (absolutely essential for Vertipreps)
- Methods aimed at reducing soft tissue trauma during tooth preparation
- Electrosurgery
- Mechanical - retraction cord
- Chemical - haemostatic solutions

FVC and MZC it is a 0.3mm chamfer margin increasing to 1.0mm occlusal. MZC margin ideal 0.5. Occlusal 1.5 for functional areas in bruxist.
For Captek and electroformed crowns a preparation of approx 0.9mm should provide enough room for an acceptable looking crown. 1.2mm should provide space for very good aesthetics. 1.5mm minimum is definitely needed for aesthetically acceptable porcelain bonded to metal crowns. Between 1.0mm and 2.0mm for the all-ceramic systems depending on system used and colour being prescribed. 1.0mm for Procera if high value shade (A1, A2, B1, B2) for example.

See U-tube for video of technique and burs used. Bur kits from Diatek:
General kit for all preps #60011104
Crown Prep Kit by Prof Brian Millar #60020102

For inlays it is essential to have a minimum thickness in any direction of no less than 2mm. Ceramic is less forgiving, unrepairable (with ceramic) and less easily adjusted than a composite material.

Immediate dentine sealing

Magne has described a procedure called immediate dentine sealing (IDS) where a filled DBA, Optibond FL, is applied immediately after tooth preparation. This is in contrast to the common practice of delayed dentine sealing (DDS) where dentine bonding is carried out just prior to cementation of the permanent restoration. He argues the benefits of minimizing pulp irritation and less need for anaesthesia on removal of the provisional crown as well as an increase in bond strength. Dalby et al showed that the application of DBAs to dentine as an IDS procedure has no statistically detrimental effect on the SBS of subsequent cementation. The IDS procedure using Optibond FL (group A), as described by Magne had a statistically significant improvement in SBS as compared to the self-etch single bottle adhesive. The higher degree of filler in the Optibond FL may have relevance to this improved SBS.

Magne P. Immediate dentin sealing: a fundamental procedure for indirect bonded restorations. *J Esthet Restor Dent* 2005
Dalby R, Ellakwa A, Millar BJ and Martin FE. Influence of immediate dentin sealing on the shear bond strength of pressed ceramic luted to dentin with self-etch resin cement *International Journal of Dentistry* 2012

Core Build-ups

Retain as much tooth as possible and utilise natural undercuts in the access cavity. Remove some GP to increase the core retention.

Decide if the missing tooth tissue needs to be replaced by a core, if so do you want to build up a core on the tooth (traditional) or make a virtual core and create the core at cementation (much quicker, better fit) or incorporate the core into the crown (eg as in an Endocrown).

For a traditional core a Nayyar-style core is preferred, use adhesive to further increase retention and a seal against bacteria and RCT failure.

Core materials:

Amalgam – slow to place and set, will compromise aesthetics and unlikely to be used nowadays

GIC – weak bond and expands (so can fracture the crown after cementation, slow to set fully. Not ideal for cores unless small.

Composite – good moisture control needed, can prep immediately, eg *ParaCore.* It is more efficient to use a dual-cure composite eg *ParaCore* rather than incrementally build up using a light cure composite

Posts
Use a post only if necessary! Beware of the risks.

Reduce the risk of perforation by:

- Keep the post as narrow as possible (may need to use a non-cast post eg. titanium, wrought gold)
- keeping the posts preparation shorter (eg. use an adhesive system)
- can use a tapered-ended system (eg. *Tenax*)
- do not use a posts at all! Use adhesive cores eg Nayyar-type, when possible.

Reduce the risk of root fracture by:

- Keeping the post preparation as narrow as possible
- Avoid rigid posts (metal), consider no post at all (best) or glass-fibre eg *Fibre-Lux*
- Always place a 1mm+ ferrule around the tooth, may need electrosurgery to expose root surface

Consider salvage potential – better to break the post than the root. But "what if the post breaks". It is easier to remove a fractured glass fibre post than a ceramic or bonded-in metal post.

Current European expert opinion is than glass-fibre should be the post of choice for anterior teeth as it flexes like dentine, reduces the risk of root fracture, can be shorter (as is more retentive), can be more easily removed if fractured (than metal or ceramic) as well as being tooth coloured, non-corrosive and non-allergenic. A review (BDJ 2003; 195: 43-48) concluded than although there is a lack of long-term clinical trials the results suggest that fibre based posts may be clinically appropriate for anterior teeth and for posterior teeth if a post is needed then a metal post is suitable.

Technique

Select the largest, straightest canal. Retain 4-5mm of GP for a metal post, bonded glass-fibre does not need to be so long. Remove GP by Gates-Glidden ± solvent to the required length. Parapost drills are only designed to widen the post hole, not lengthen it. Use narrowest size possible to maintain root dentine and strength as well as reduce the risk of perforation and root fracture. If the post itself is thin (perhaps less than the "red" in size) then avoid a cast post – use a wrought post to cast a core onto or place a direct core onto a titanium post. In aesthetic situations consider a glass-fibre post with composite core if using an all-ceramic crown.

All teeth need a ferrule if a post is placed. This means that the core or crown margin must extend 1mm apical to the base of the core to reduce the lateral movement of the crown and core placing stress on the post and root. An antirotation design is essential: utilise the remaining tooth where possible.

Temporary restorations

Where the gingivae are inflamed due to poorly fitting margins or caries associated with existing restorations these may need to be removed and well-fitting temporary restorations placed. This will allow for improved oral hygiene and for healing to take place. Long-term temporaries will also give you the opportunity to assess the design of the final restoration, for example: aesthetics; contour; emergence profile; occlusion and periodontal health.

Where temporary crowns or bridges are to be in place for more than a few weeks it would be advantageous to use a bis-acryl type material. These auto-cure, composite resin based materials are more aesthetic longer-term and will not wear or stain like the methacrylate-type materials. Once the temporary restorations have been adjusted and considered to be a useful guide to the design of the final restoration an impression of them can be recorded while in place to act as guide to the technician. A putty impression is useful here and should you damage the temporary restoration on removal then this impression can also be used to construct a chairside replacement.

It can be useful to make the temporary restoration before taking the impression to warn you of undercuts or inadequate occlusal reduction. A temporary crown or bridge can be made in the pre-operative putty impression and which can then be used to form the final impression to save chairside time. Some of the bis-acryl composite temporary crown and bridge materials leave a residue on the putty surface which needs to be removed or cut out.

Provisional Restorations

Provisionals are so much more than something that keeps the prep covered and comfortable while definitive restoration is being made. They are diagnostic i.e. with an attrition case once the tooth is prepared and impression is sent to the lab how does the technician know where to put incisal edge? A pre-op diagnostic wax-up on an articulator will allow you your best guess. The provisional is made according to the wax-up – they are then taken to the mouth and using the same principal as one would for removable prosthodontics – lip support, basic aesthetic appearance – the provisionals can be lengthened, shortened, incisal edge moved back or forward almost anything to get the result that one likes. When the patient says YES they are happy with appearance etc. the provisional can be copied to provide the shape for the final restoration.

Tooth Shade Matching

Shade matching is difficult. In smile design a new shade is selected so easy: identify the before and after colours then allow 0.25mm ceramic for each Vita value step. Pre-bleaching reduces the need for think ceramic.

Interpreting the shade for shade matching is a great problem in fabricating restorations hence clinicians resort to multiple restorations! Colour as we see it is determined by radiation from the light source, modified by the object, and interpreted by human vision. Even given identical structure of the human retina in various individuals, interpretation of colour remains subjective because of differences in colour perception faculties. The ability of the eye to perceive colour begins to decline in the third decade of life, as slow yellowing of the lens begins. An operator's eyesight tires at the end of a difficult tooth preparation under strong light or toward the end of a long day and he or she may not distinguish shade nuances as well.

Consider:

- Environment
- Light Source
- The dimensions of colour: Hue, value, and chroma
- Instrumentation for shade matching/taking
- Using different shade guides, eg. 3D master, Chromscope.
- Shade guide Modification

Check lighting, do at the beginning of the appointment (when teeth are not dehydrated and your eyes are less tired) and take shade outdoors if possible.

Check the value first based on middle 1/3 of the tooth, then move to other areas.

The shade guide should be set up in value order as detailed below:

B1 - A1 - B2 - D2 - A2 - C1 - C2 - D4 - A3 - D3 - B3 - A3.5 - B4 - C3 - A4 - C4

Look for no longer than 8 sec then look a blue surface. Squinting may help.

Check hue (A-B-C-D): A = red-brown, B = red-yellow, C= grey, D red-grey using the upper canine

Electronic systems are good but need manual checking to confirm the shade. They are particularly good for monitoring bleaching.

Choosing an impression technique

It is important to develop an impression technique which the clinician is confident and competent with and so will become reliable and predictable. Today we will use Coltene's Affinis material designed to flow well over preparations and prevent voids.

Prepared teeth need to be clean and dry, and a technique for applying the wash material without trapping bubbles is essential. A useful tip is to inject a little wash material over the tooth then air disperse the wash material using a gentle stream of dry air from the 3 in 1 tip. This pushes the material over the prepared surfaces, into crevices and corners and into the gingival sulcus, as well as creating a thin layer which trapped bubbles can burst through. This technique increases the flow of a material (due to the effect of pseudoplasticity) while preventing slumping and dripping of the material off the prepared tooth. Further wash material is then applied.

Voids are often created on the distal aspect of the maxillary teeth. This is usually due to the application of too much light body material, which gravity then pulls away and the slumped material is then pushed distally as the unset putty is inserted. Solutions to this problem are to air disperse the wash material into a thin layer which will not slump, use a two stage putty-wash technique or use a close fitting special tray.

Custom tray with low and medium body addition silicone material

The "gold standard" method is probably still a custom tray containing a medium body or heavy body addition cured silicone material with a low viscosity material syringed intra-orally, a dual-phase technique, addition silicone in conjunction with a meticulous clinical technique. This allows for maximum flow and so a reduced risk of surface bubbles, excellent surface detail and a minimal amount of impression material.

It is, of course, possible to use a heavy body material in a stock tray with light body on the teeth although this will incur higher costs as more heavy body will be required. An advantage in using an automixed heavy body to replace a putty is the gloves do not need to be removed and hands washed before mixing!

So how can you decide which to use?

It depends on your preference for a putty-wash, two-phase or monophase technique.
The use of an addition silicone putty/wash technique offers a slightly more economical alternative and should be used in a rigid stock tray. There is little difference in accuracy between the one stage putty/wash and the two stage method where a spacer sheet was used. However, a two-stage technique where the initial putty impression is recorded without a spacer, or where no space or sluice was created, is not recommended. A relatively rigid material such as a polyether or a putty should not be used in a close-fitting rigid tray.

Putty-wash can be single-stage, two-stage, two-stage with spacer. Two-phase uses a lower viscosity than putty (eg, a heavy body in a stock tray or a medium body in a special tray). Monophase is placed

in the tray first (so it reaches a higher viscosity) while syringing more material around the preparation, utilising the property of shear thinning by using a small diameter syringe tip and air dispersion.

The majority of dentists use a putty-wash technique of which there are various options:

- putty and wash together
- putty then wash
- putty, then sluices cut, then wash
- putty with a spacer sheet, then wash
- Putty with wash in the injection moulded technique

Putty and wash together

This is probably the favourite technique in general practice in the UK; it has the advantage of speed, particularly when a fast set putty is used with a light body wash. Cost is reduced by use of the less expensive putty material in a stock tray.

A disadvantage with this technique is that the high viscosity putty tends to push the light body wash off the prepared tooth. The wash material then ends up in the lingual and buccal sulci and the critical areas, such as preparation margins, are recorded with putty which does not pick up fine detail. This can a particular problem when the preparation margin is high on the tooth, such as for inlays, onlays and ¾ crowns. Clinicians using this technique need to consider using a putty and light body with viscosities as closely matched as possible: a soft putty and a relatively higher viscosity wash.

Putty then wash as two separate stages

The disadvantages include the additional time of having to wait for two materials to set, contamination of the putty with saliva, which may prevent light body adhering to it, and difficulty in reseating the putty in the mouth. There will be distortion of the putty or tray as the wash material is compressed and a tendency to force the wash out of the impression. Some wash material may pass along the occlusal surfaces of adjacent teeth resulting in an occlusal discrepancy on the model.

Putty, with trimming and sluices cut, then wash

The putty impression is recorded at the beginning of the appointment and then a buccal sluice is cut for each prepared tooth. An area around each prepared tooth is also cut out with the putty knife.

This method offers an improvement to the standard two-stage putty wash technique as the sluices allow for excess material to escape into the buccal sulcus rather than spread along the occlusal surfaces of the adjacent teeth. Space is also created for the prepared tooth area to enable it to be recorded with sufficient wash material allowing the reproduction of much greater detail. Furthermore, as a fresh putty surface is created the risk of wash material debonding is less. This

represents a good technique for putty-wash although additional time is required for cutting and trimming the set putty.

Putty with a spacer sheet, then wash

The putty is first inserted into the mouth with a spacer sheet on the putty surface. This spacer prevents the putty taking a detailed impression of the teeth. It also prevents contamination of the putty by saliva while conveniently providing sluices in the putty. The putty is removed immediately and allowed to set outside the mouth. Any distortion of a plastic tray will now be eliminated. The polythene sheet is peeled away prior to recording the final impression when a light body material is placed on the teeth and in the putty trough. This technique is quick and reliable. More light body will be needed for this method but the teeth will be recorded in light body with high detail but at a higher cost.

Putty with wash in the injection moulded technique

My preferred technique is to record a pre-operative putty impression in a fairly rigid plastic stock tray. I make a temporary crown using the putty impression then cut away some putty around the prepared tooth and cut a buccal sluice channel. A hole is drilled through the putty from the outside via a perforation in the plastic tray into the prepared tooth area. The tooth is dried, the putty inserted into the mouth a seated. Hold the tray down on the teeth while light-body material is then injected through the hole until it escapes via the sluice channel. A great technique for patients with large tongues and for impression repairs

Choosing a tray

The tray needs to be fairly rigid to prevent the putty distorting the tray, particularly during a single-stage, putty-wash technique. Subsequent stress relief will cause distortion. A metal tray is ideal in eliminating tray distortion but dentists must ensure that the tray is not too tight a fit and that there are no significant undercuts, loose teeth or bridges. Something has to "give" if an impression is to be removed from such undercuts! If the tray is rigid then the impression material itself has to distort and recover from the distortion. If in doubt, a rigid plastic tray is safer, still eliminating distortion by the putty during insertion but it will flex during removal if necessary. It would allow for easier removal should the tray become stuck! Plastic trays can be flexed manually and be cut if necessary. Impressions which become stuck in the mouth, or are difficult to remove, tend to be a combination of a rigid material (such as *Impregum* or a silicone putty), in a rigid tray (which could be metal, rigid plastic tray or custom tray) particularly where the tray is too close fitting.

The majority of dentists use a stock tray (75%) and a putty-wash technique (90%). However, metal and rigid plastic trays are generally preferred as they offer greater accuracy in the putty-wash technique. If using a rigid tray check carefully for intra-oral undercuts and choose an impression material accordingly.

Special trays

Most authors refer to the advantages of a rigid special tray to provide a uniform specified thickness of impression material offering reduced distortion, improved dimensional accuracy and fit of restoration. However, not all research studies are in agreement on this.

Flexible plastic trays are certainly not advised for elastomeric impressions for prosthodontics. They may be considered for low viscosity materials such as alginates for study casts only. If a non-rigid plastic tray is used with putty the tray will distort during insertion. On removal from the mouth the tray may partially rebound or remain distorted which will compromise the dimensional accuracy of the die.

Dual-arch impression techniques

A review of the literature suggests that the use of a flexible tray results in inaccuracy when compared to the use of a rigid tray as would be expected. Interestingly, studies which show that impressions recorded using the dual arch technique (DUAT), eg. using a *Triple-Tray* which provide no lateral support, provide as satisfactory a fit and no loss of dimensional accuracy as single arch techniques for single tooth restorations. This suggests that the distortion from a flexible plastic tray may be greater than that when using a rigid tray or a self-supporting putty in the DUAT. One particular advantage of the dual-arch technique is its ability to reduce wretching.

Dual-arch impression techniques are popular for limited use in patients with class I occlusion with posterior disclusion for single-tooth restorations. Provided their limitations are understood then the results have been shown to be as good as full arch impression techniques. Perhaps best restricted to using with patients who easily wretch but may be suited to older patients with limited opening.

A bonding update for cementation of indirect restorations

There has been a sustained move from cementation to adhesive bonding as clinicians move away from cast restorations to aesthetic materials (Figure 1). In line with this there has been a shift away from cements to adhesive bonding, requiring the use of self-cure luting composites, often these are dual-cure and may be self-adhesive or require the use of a bonding resin.

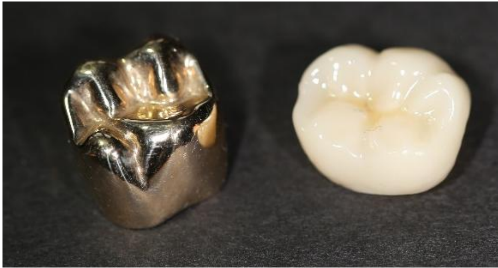

Figure 1: Traditional gold crowns (left) and metal-ceramic crowns can be cemented, eg zinc phosphate and have exceptional survival rates in practice of close to 50 years[1]. They can also be adhesively bonded. Aesthetic indirect restorations (right) require more complex adhesive bonding techniques.

Indirect restorations usually fail at the margin leading to caries, sensitivity, pulp death and apical infection. So a good seal is critically important to survival of the tooth, never mind the restoration. Clinicians should have their focus on tooth survival and periodontal health rather than longevity of the restoration. Before looking at materials the technique itself is important particularly regarding the clean-up. We know the dangers of excess material particularly to the periodontal tissues. Much better to avoid it than try to detect it and remove it later.

Technique:

Explain to patient that some post-op sensitivity may occur and they will need to adapt to the new shape and occlusion. Given that the provisional restoration was unlikely to be perfect and probably has had some occlusal wear the occlusion will have changed since the impression was recorded. Assuming the restoration was fabricated correctly to the correct occlusion then it will fit correctly at the time of the impression but not a few weeks later. So knowing the occlusion is unlikely to be correct as the tooth has moved since the impression was recorded it is worth telling the patient this beforehand, that the occlusion will be close but they will be aware of it and it will self-correct in a few days.

Cementation Technique

Explain procedure to patient

Remove provisional restoration and clean tooth surfaces

Block out interproximal areas eg PTFE tape (fig 2)

Place restoration with luting material and hold in place

Remove the PTFE pulling buccally to remove excess

Use a *TePe* to remove remaining interproximal excess

Microbrush to clean buccal margin

3 sec light only on buccal aspect then release seating pressure

3 sec light only on lingual aspect

Physically remove partially set material with semi-sharp instrument (amalgam carvers are ideal for this, and you probably have plenty of them)

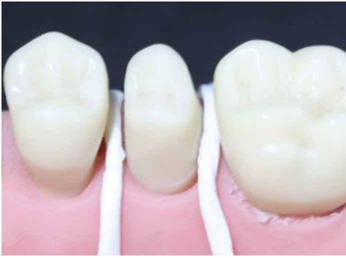

Figure 2: Pre-packing PTFE tape under the contact areas reduces the spread of excess luting material into this problematic area and assist in its removal.

Still feel the need to check the occlusion? If you are testing it then patient needs to be upright if checking ICP. Not much to be gained by checking occlusion with patient lying flat you might get something close to RCP but that's not usually a functional position.

Tooth preparation

Avoid crowns where possible as they weaken teeth by removing coronal tissue. Many root-filled posterior teeth will benefit from occlusal coverage, so consider partial coverage where possible. Overlays are ideal for this particularly when made from metal. Where there is sufficient bulk of restoration it is worth considering indirect composite to obtain high end aesthetics, ease of adjustment, wear rates similar to teeth.

Where a full coverage crown is indicated minimise the damage by using vertical margins Figure 3A) where possible – as they are less destructive than traditional horizontal margins such as shoulders and chamfers[2].

If a patient presents with a very broken down tooth it is possible at the first appointment to only prepare the margin and 2mm ferrule zone (Figure 3B), record the impression and fabricate the crown, which will be a shell of ideal thickness for that material fitting exactly to your prepared margin and ferrule (Figure 3C). At the fitting appointment the old restoration and caries is removed, RCT if necessary, post placed if necessary, then the crown is luted as before with the core being fabricated inside the crown with the usual self-adhesive self-cure composite material. This is a time saving technique as it avoids the need to build a core then prepare it. An alternative approach is the endocrown (Figure 3D) where the core is fabricated as part of the restoration from a CADCAM block. For broken down teeth a 2mm ferrule is considered essential[3]

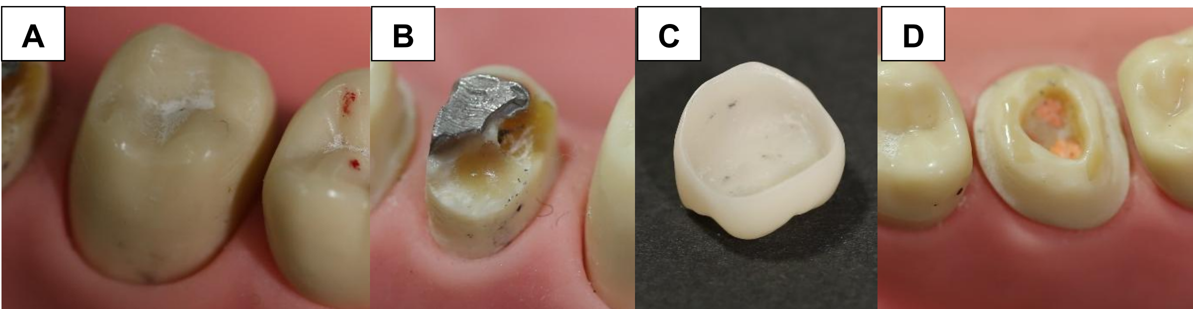

Figure 3: A- a vertical margin on 16. B- the core made in the crown technique which is possible with self-cure luting materials. C- the shell crown fabricated to fit the prepared margins and ferrule. D- an Endocrown prep.

Consider Immediate Dental Sealing (IDS) after tooth preparation[4]. A routine self-etching bonding agent can be used for this and is applied as soon as the tooth preparation is completed. Then marginal refinement can be carried out. A good barrier layer must be used prior to fabricating the provisional restoration due to the increased risk of the resin-based provisional resin bonding to the adhesive IDS layer. At the fitting stage the tooth is cleaned then the bonding stage is repeated by applying the bond as normal.

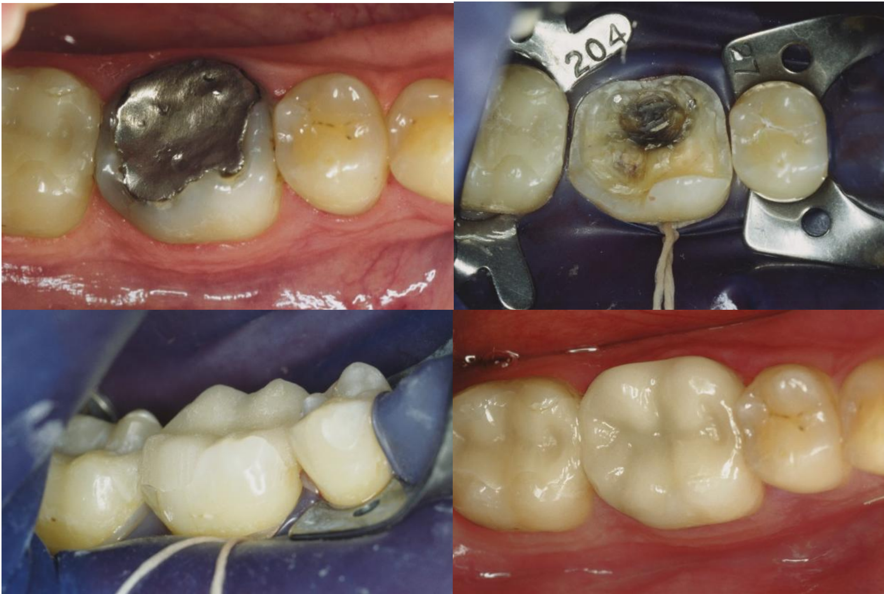

Figure 4: An example where a full coverage crown would have weakened the carious tooth. This partial coverage CAD-CAM restoration restored the tooth with less tooth tissue loss.

Ideally the adhesive luting material should bond to both tooth and the restoration, be tooth coloured and easy to use. Ease of use would include: syringeable, dual-cure, suitable viscosity and no need for separate etch and bond stages. One of the first was *ParaCore* (Coltene) in 2004 and although this was designed as a core build-up material it's flow properties, dual-cure and colour made it suitable as a luting cement with excellent results and the lowest marginal leakage in a study[5] (Figure 5).

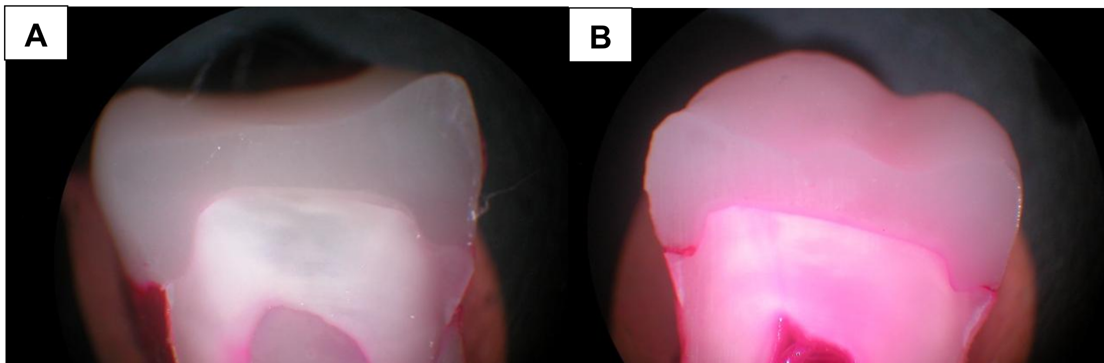

Figure 5: Left - *ParaCore* used with self-cure bond (ParaBond). Right – a competitor material without self-cure bond showing margianl leake with a dye in vitro.

<u>Adhesive Bonding Technique for non self-adhesive materials</u>

Total etch (enamel + dentine)

Apply the self cure bond

Place restoration using

ParaCore/DuoCem

Clean up, 3 sec light, clean up, 20 sec light

However *ParaCore* is non-adhesive and so required a separate bond stage (eg *ParaPost* adhesive Figure 6A) as did many other materials at the time and appeared to provide improved marginal seal over materials that did not have a self-cure bond as shown in Figure 5.

ParaCore and other non-adhesive materials would be used with a separate bond as shown on the left.

This would apply to the many earlier luting materials that are not self-adhesive and require the application of a bond before seating the restoration with the luting cement, eg *Nexus, Calibra, DuoCem.* Note that the popular luting materials in the *Panavia range* also have a separate bond stage.

Two points often ignored is that this bond should be self-curing and compatible with the luting composite. If a normal light-cure bond was to be used and the bond is painted on the tooth surface and light cured, as in the direct composite technique, then the thickness of the cured bond layer can inhibit seating of the restoration with disastrous consequences: bonded on "high" with a marginal gap and high occlusion. This is particularly a problem with inlays as the bond can puddle. On the other hand if the bond is applied and not light cured then it will be ineffective. Not using a bond at all will reduce bond strength (see DATA).

The solution at the time was to use a self-cure bond – *Panavia* materials required mixing drops from two bottles, similar to *ParaCore* (Figure 6A). Other companies produced an Activator to be mixed 1:1 with the normal light-cure bond such as Prime&Bond NT by *Dentsply* (Figure 6B) and One Coat 7 Activator by Coltene (Figure 6C) designed to neutralise the acidity of the bond which tends to inhibit the curing of the luting composite.

Figure 6: Examples of methods to overcome the problem of uncured bond with indirect restorations. A- two bottles are used to create a self-curing bond. B-activator from Dentsply used with the normal bond (Prime&Bond NT) to convert it from light cure to self-cure. C- Activator for *OC7* (Coltene) to reduce acidity to prevent inhibition of *DuoCem* luting composite, not required with *SoloCem*.

Further evolution and development resulted in built-in adhesives bringing us to the popular current materials in this range such as: *Rely-X Unicem* (3M) and *SoloCem* (Coltene). These are designed to be used directly on to the tooth without the need for acid-etching or application of a separate bond. However the use of acid etch and bond application does generate higher bond strengths (see DATA).

SoloCem can be used with a bond layer if the clinician chooses to improve bond strength. It is designed so that the acidity of the self-etch bond does not affect the luting composite. So the technique becomes simpler as shown on the right. These are designed to be used as self-etch luting materials, ie: clean the tooth surface then seat the restoration coated with the luting materials and clean up as before. Ideal for placing indirect restorations where most of the tooth surface is dentine.

Adhesive Bonding Technique for self-adhesive materials (eg *SoloCem*)

Remove provisional

Clean tooth, (etch any enamel present if you choose)

Apply the bond self-adhesive bond in a thin layer, avoid pooling and light cure

Seat restoration with *SoloCem*

The universal cements such as *RelyX Unicem* and *SoloCem* give the clinician the option to use an additional self-adhesive bond or not, as well as acid-etching enamel.

The only downside is that the bonding to any enamel present will be less than ideal. This is apparent from the shear bond strengths listed in the appendix. So to improve this then the selecting etch technique can be added.

So etch the enamel (not dentine) with standard 35% phosphoric acid gel for 25 sec, wash and gently dry. The proceed as before with the self-adhesive luting technique. This is shown in blue in the table above. This will give optimal bonding to enamel and dentine. I would consider this essential when bonding a metal framed resin bonded bridge to enamel.

Be careful not the get the acid-etch on adjacent teeth otherwise clean up becomes more difficult. Ideally protect the adjacent tooth with a barrier (Figure 7).

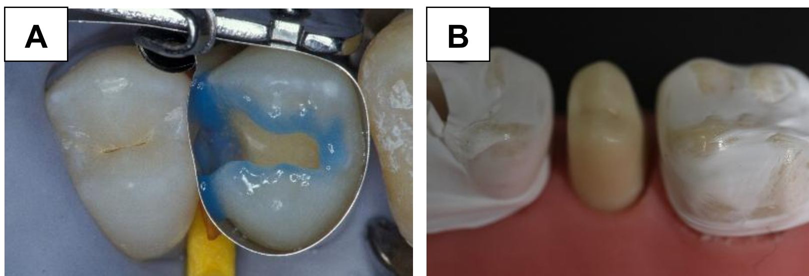

Figure 7: A - a traditional circumferential matrix can be quickly applied to prevent acid etch spread to adjacent enamel surfaces. Note: sectional matrices are preferrable for placement of direct restorations. B - the use of PTFE tape to protect adjacent teeth.

Conclusions:

There is good reason to simplify luting restorations. The new universal self-adhesive luting composites are a help to clinicians but have reduced bond strengths as a consequence. This can be enhanced by adding the options of:

a) use with acid-etching enamel where necessary, and
b) use with an additional bond layer to improve bond strengths

References

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2 Stack J, Millar BJ. Analysis of zirconia crowns with vertical margin preparations. Eur J Prosthod Rest Dent *in press*
3 Marchionatti AME et al. Clinical performance and failure modes of pulpless teeth restored with posts: a systematic review. Braz Oral Res. 2017 Jul 3;31:e64.
4 Dalby et al. Influence of immediate dentin sealing on the shear bond strength of pressed ceramic luted to dentin with self-etch resin cement *International Journal of Dentistry* 2012]
5 Millar BJ, Deb S. An in vitro study of microleakage comparing total-etch with bonding resin and self-etch adhesive luting cements for all-ceramic crowns. *Open Journal of Stomatology* 2014 4 126-134]

Materials list

Composites:
MIRIS2 Tips 8465/MIRIS2 Syringes 8431
BRILLIANT EverGlow System Kit Syringes (9 syr) 60019722
BRILLIANT EverGlow System Kit Tips (60tips) 60019723
Inspiro – Henry Schein/Optident/Edelweiss
PTFE – for water pipes
SwissFlex polishers– Kit 250095AA
Universal bond – Bottle refill 5ml 60019539, single dose kit 60019540 (50pcs)
Bond (Optibond FL) - Kerr
Hygienic rubber dam kit – Starter kit with winged clamps H02778, Starter kit with plastic carry case and winged clamps H02782, Complete kit with Wingless clamps no carry case H02790
Garrison matrices anterior and posterior

Impressions:
Putty, fast set Affinis – AFFINIS fast putty soft 6531
Affinis Heavy Black – 360 refills 60019776
Affinis light Green – AFFINIS LIGHT BODY 50ml 6501/ FAST LIGHT BODY 50ml 6601
Putty knife – 4420
Clear silicone matrix material – *GC Exaclear, Elite HD glass*

Posts:
Parapost (parallel or Tenax (part-taper), both in metal or glass fibre (Fibre-Lux) *Coltene*

Provisionals:
CoolTemp – COOLTEMP Single Pack A2 5805
Paint-on colours - 7330
QuickTemp varnish for provisionals (Schottlander)
TempoSil2 silicone cement

Equipment:
Bur Kits Diatek: general kit for all preps #60011104; Crown Prep Kit by Prof Brian Millar #60020102
Portable surveyor
Articulators: Bioart 4000S & Professional facebow – Panadent or Denar 330 - Prestige
Shade: Vita linear shade guide - Panadent
Handpieces: speed increasing *W&H* 99, ceramic bearings, LED light

Other restoratives:
Biodentine – Septodont
Fill-Up, Coltene (a Bulk-fill, dual cure restorative)

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