

Clinical applications of polytetrafluoroethylene (PTFE) tape in restorative dentistry

M. M. Sattar,^{*1} M. Patel² and A. Alani³

In brief

Compares the use of plumber's tape to existing dental materials and discusses potential areas where it can be used as an alternative to assist in restorative dental procedures.

Provides clinicians of all experience levels with exposure to an alternative dental material along with some techniques for its use.

Outlines the use of a simple, cost effective and readily available material to enhance restorative dental procedures, further expanding the clinician's armamentarium.

Restorative dental procedures are ever developing; one reason for this can be attributed to newer materials with better handling properties and our ability to manipulate them more effectively. As a result various techniques have been described to aid clinicians in obtaining predictable results in restorative dental procedures. This article aims to review the use of plumber's tape to assist in adhesive, endodontic and implant related dental procedures, when compared to other available materials.

Introduction

Polytetrafluoroethylene (PTFE) is a polymeric material that has common uses outside of dentistry. Its applications include incorporation into cookware and building materials as well as within circuitry and components for computers. In dentistry it has been used for purposes of guided tissue regeneration, the coating of instruments to improve handling properties and clear-based matrices.^{1,2} More recently the use of PTFE for purposes of screw access channel filling has been described.³

PTFE is relatively inert; as such it is capable of resistance to solvents and acids, therefore will not degrade when used with dental etchants.⁴ PTFE also has a low static and kinetic coefficient of friction (0.1) ensuring a 'non-stick' application and removal without leaving behind a residue.^{5,6} Due to PTFE's 'high break elongation' it is capable of being stretched up to 400% of its original length without tearing. As such the material can be stretched and adapted closely to different

surfaces and manipulated without the risk of being destroyed.⁶ Despite the material being available in thin sections (30–120 μm) it does not significantly lose its shear strength (Fig. 1). In addition to excellent insulating properties,

PTFE has a high melt viscosity (approximately six times that of most fluoropolymers) which allows the tape to be sterilised for dental purposes in an autoclave (Fig. 2).^{4,7} These qualities suggest a number of potential uses in restorative dentistry.

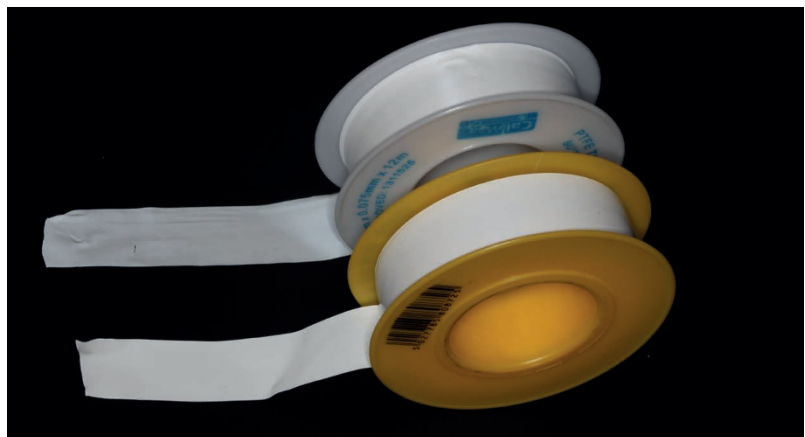


Fig. 1 Spools of PTFE tape purchased from a local hardware store. The white casing represents a thinner gauge used for sealing water pipe threads. The yellow case below has a double thickness tape, which is utilised for sealing gas pipe threads



Fig. 2 A strip of PTFE tape supported by a tongue depressor within a sterilisation pouch, after being autoclaved. The PTFE tape remains unchanged due to its high melt viscosity

¹General Dental Practitioner, Grants Dental Practice, 52 High Street, Royal Wootton Bassett, Swindon, SN4 7AQ; ²Specialty Dentist in Prosthodontics; ³Consultant in Restorative Dentistry, Department of Restorative Dentistry and Traumatology, Kings College Dental Hospital, Denmark Hill, London, SE5 9RS

*Correspondence to: Mohammad Sattar
Email: msattar13@gmail.com

Refereed Paper. Accepted 21 November 2016
DOI: 10.1038/sj.bdj.2017.110

©British Dental Journal 2017; 222: 151-158

This review aims to illustrate some contemporary applications for PTFE in clinical dentistry citing advantages and disadvantages when compared to other available materials (Table 1).

Dental applications of PTFE

PTFE as a barrier material

Historically, PTFE has been used as a barrier against soft tissue ingress of a healing site to promote bone tissue formation. This quality can be developed further for clinical scenarios in restorative dentistry. When managing dental materials and their interface with hard or soft tissues PTFE has some useful applications especially when cementing or bonding restorations.

Adhesive dentistry

The restoration of anterior teeth with the direct bonding of composite for aesthetic or tooth surface loss purposes is well established.^{8,9} Metal and plastic matrices are a common method of interdental separation in bonding procedures. Using a separating medium ensures the proximal surfaces of the adjacent teeth are not etched and bonded; thus preventing iatrogenic bonding within the contact area. This can create a nidus for plaque retention and impede the patient's ability to clean inter-proximally.

Common interproximal matrices include clear Teflon and cellulose acetate strips. These strips are advantageous as they allow for the photo-activation of the resin through the clear matrix.¹⁰ The clear matrix also allows the operator to contour the restorative material to the desired shape without losing visual access of

Table 1 Shows various uses of PTFE tape in restorative dentistry

Material	
Barrier material	1. Adhesive dentistry
	2. Eliminating sub-gingival cement lute stagnation
	3. Protecting implant abutment screw heads during sealing of screw access channels
	4. As a barrier between the access cavity and root canal system
Spacer material	5. Utilising PTFE as a spacer for restorations
Recovery material	6. Block-out material for impression making
	7. Trial seating of extra-coronal restorations

the intended restoration. However, due to their shape memory clear matrices can be difficult to stabilise and may cause matrix malformation of the material during placement, resulting in suboptimal contour.¹¹ Clear plastic matrices are typically manufactured in a gauge of 0.002 inches, which may inhibit the formation of an optimal proximal contact, the complete seating of a resin bonded bridge retainer or adhesive onlay during cementation.¹²

The rigidity of clear plastic matrix systems also interfere with the use of customised tooth mould indices made from either polyvinylsiloxane putty, clear polyvinylsiloxane bite registration material or clear vacuum formed polyvinyl acetate. These useful adjuncts along with a diagnostic wax-up can aid the clinician when restoring worn teeth with composite resin (Fig. 3).¹³

When stretched PTFE tape can provide a thin interdental separator and the formation of a well-approximated restorative contact area.^{11,12} To facilitate placement of the PTFE tape

between contacts that are difficult to negotiate, a wedge or flat plastic instrument can be used to temporarily separate the teeth. A micro brush or sable-hair brush will help to remove folds or creases that may occur during placement and stretching through the interdental contact area, ensuring close adaption to the dry tooth surface (Figs 4 and 5). When restoring posterior teeth PTFE may assist in the adaption of the matrix to the tooth along with establishing an anatomical tooth contour. Where a large embrasure exists PTFE can be compacted into the proximal space to contour the matrix to achieve the desired shape (Fig. 6).

The application of PTFE tape will not interfere with a tooth mould index or the seating of an indirect adhesive restoration, and so aid correct positioning and seating. These features enable its use as a separating medium during composite restoration placement whether free-hand or under a tooth mould index or when cementing an adhesive restoration (Fig. 7).

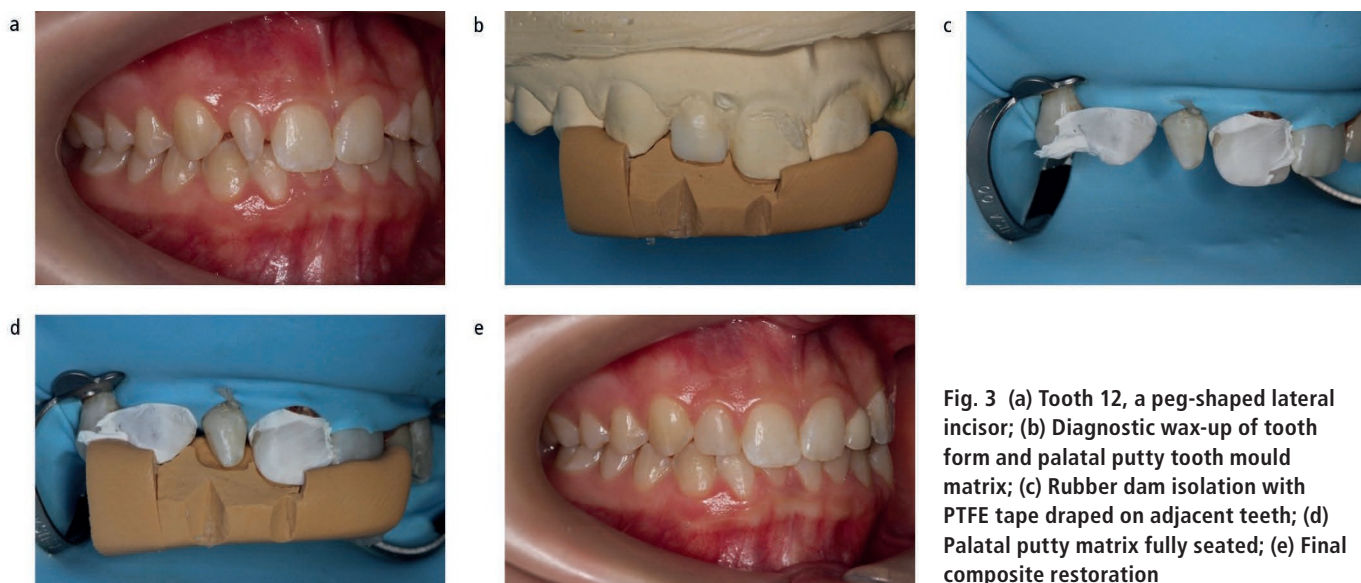


Fig. 3 (a) Tooth 12, a peg-shaped lateral incisor; (b) Diagnostic wax-up of tooth form and palatal putty tooth mould; (c) Rubber dam isolation with PTFE tape draped on adjacent teeth; (d) Palatal putty matrix fully seated; (e) Final composite restoration

Eliminating sub-gingival cement lute stagnation

Removal of excess cement lute is crucial during the placement of definitive implant or tooth borne restorations. This is essential in the presence of sub-gingival finish lines and the use of insoluble resin luting cements.¹⁴ Failure to do so can result in a deposit-induced inflammatory response of the periodontal or peri-implant tissues from plaque and bacteria stagnation. This is well known around indirect adhesive tooth-based restorations. However,

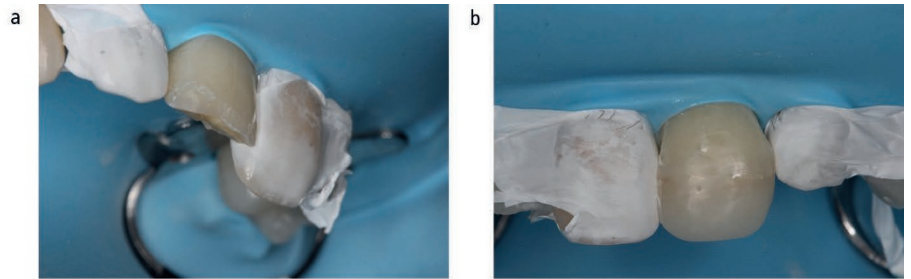


Fig. 4 (a) PTFE tape stretched and draped around the adjacent teeth prior to restoration of tooth 21 with composite. Note the close adaption of PTFE tape to the teeth; (b) Composite restoration of tooth 11



Fig. 5 (a) Tooth 21 an unaesthetic incise-edge composite restoration; (b) PTFE tape draped over the adjacent teeth; (c) The finished restoration (note the well-adapted contact)

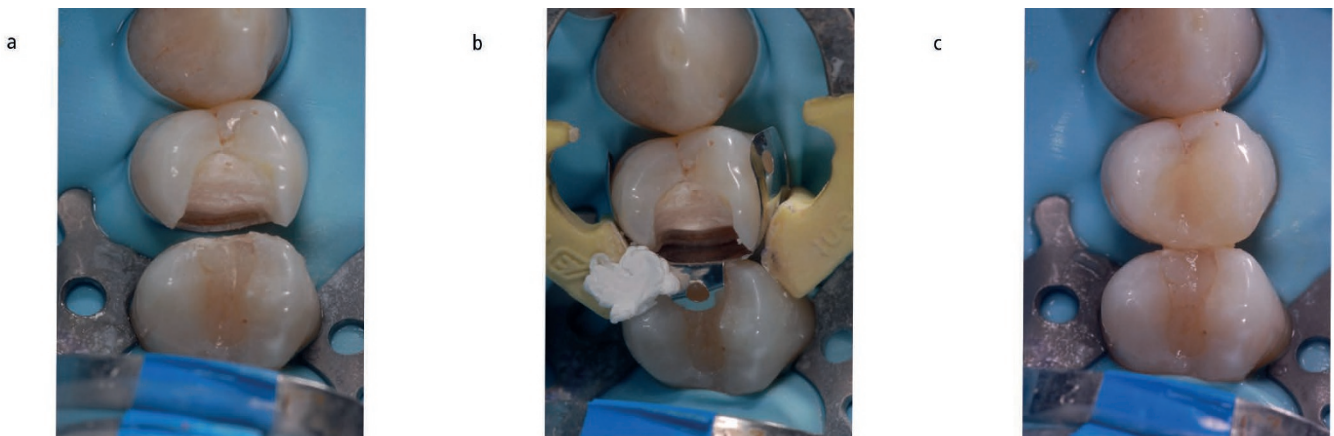


Fig. 6 (a) Tooth 24 disto-occlusal cavity preparation for restoration with composite material. Note the resulting wide bucco-palatal embrasure after loss of the marginal ridge; making matrix adaption challenging; (b) PTFE tape is packed between the sectional matrix and adjacent tooth to achieve an anatomical tooth contour; (c) The completed restoration.

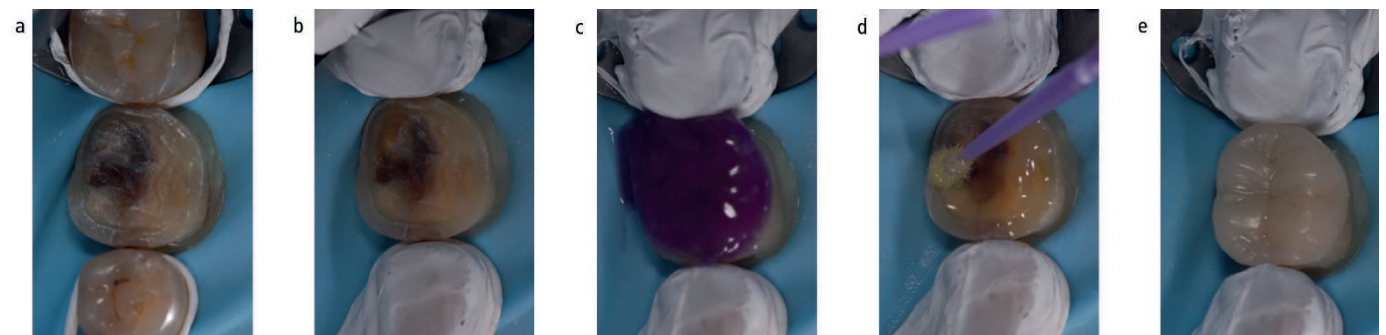


Fig. 7. (a) Tooth 36 isolated for the adhesive cementation of a ceramic onlay, PTFE tape is twisted and passed inter-dentally to block out the interdental embrasure; (b) The adjacent teeth are draped with PTFE tape teeth to protect from the etching and bonding procedures; (c) Etching of the tooth surface; (d) Application of the bonding agent; (e) Ceramic Onlay post-cementation after removal of excess cement

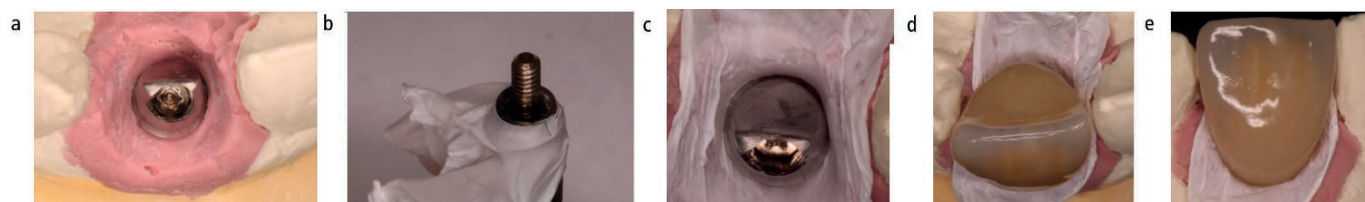


Fig. 8 (a) A lab model implant abutment with a sub-gingival finish line; (b) PTFE tape draped around the collar of the implant abutment; (c) Occlusal view of implant abutment seated (note the circumferential finish line visible with PTFE overlaying the soft tissues); (d) Implant crown fully seated (e) Occlusal view showing implant crown seated. (Lab model courtesy of Carl Abbott, Head of Restorative Dental Technology, Morriston Hospital)

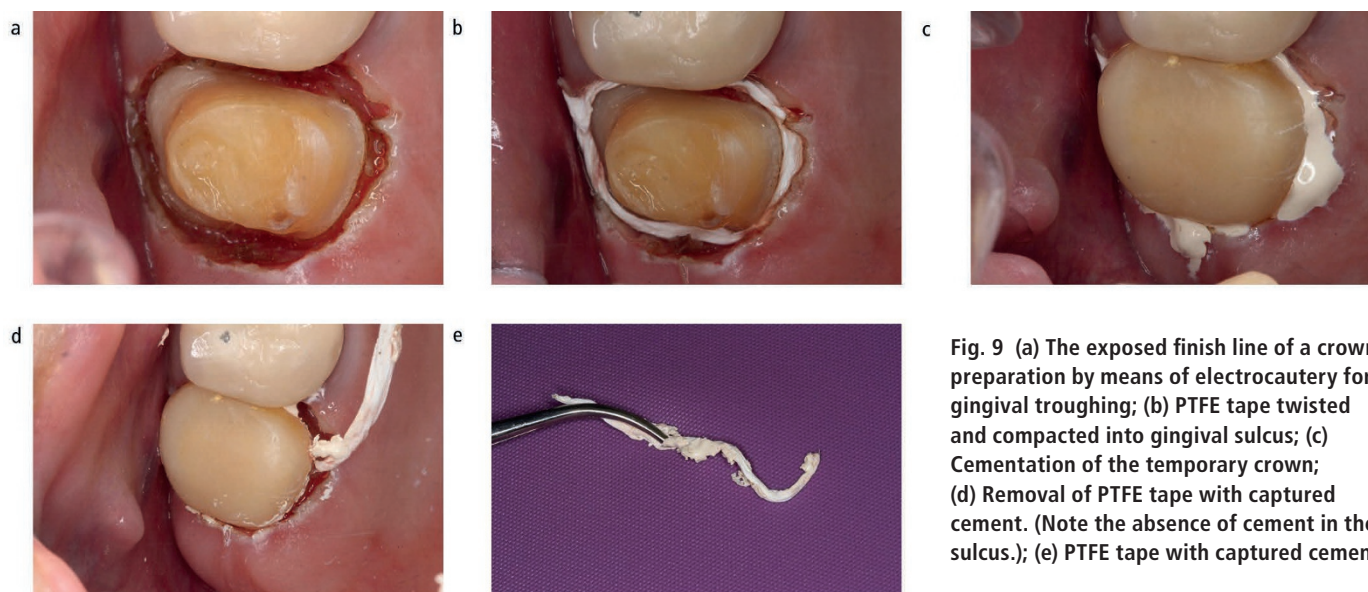


Fig. 9 (a) The exposed finish line of a crown preparation by means of electrocautery for gingival troughing; (b) PTFE tape twisted and compacted into gingival sulcus; (c) Cementation of the temporary crown; (d) Removal of PTFE tape with captured cement. (Note the absence of cement in the sulcus.); (e) PTFE tape with captured cement

it has also been shown around implant abutments for cement retained implant prostheses, where the peri-implant tissue's capacity to respond to plaque is reduced.¹⁵ The retention of set radiolucent resin cements in the gingival sulcus can elicit a chronic soft tissue inflammation or mucositis, which in turn may result in the eventual progression to peri-implantitis, the irreversible loss of bone around dental implants.¹⁶

Methods to prevent infiltration of cement subgingivally have been described.¹⁷ Extra-oral cementation for implant prosthesis has been suggested, using a duplicate core and die spacer to act as the cement space; however this method is time consuming and requires the use of cement with a long working time.¹⁸ The use of retraction cord has been discouraged around peri-implant tissues due to the risk of exceeding the peri-implant tissue capacity to resist the placement pressure, leading to damage to the biological seal around the implant.¹⁹ The potential increase in gingival sulcular space caused by the compaction of cord may result in the down flow of cement

apically and entrapment of the cord.²⁰ The cord itself consisting of multiple interwoven cotton strands can become impregnated with cement resulting in difficulty with removal from the sulcus. PTFE is comparatively impregnable without strands or filaments.

PTFE tape can provide an atraumatic barrier to protect peri-implant tissues during cementation, with added advantage of ease of retrievability. PTFE tape is available in a thickness of 50 µm providing a thin barrier and preventing aggressive retraction of the gingival sulcus causing trauma to peri-implant tissues.

By stretching PTFE tape around the implant abutment to form a protective 'bib' it is possible to create a physical barrier to prevent apical migration of cement.^{5,20} The tape can then be teased out without causing damage to the peri-implant tissues (Fig. 7). The application of PTFE as a barrier may also be extrapolated to tooth borne crowns to aid in the removal of any cement flash when cementing temporary of definitive crowns with subgingival margins, whereby the tape is placed circumferentially below the gingival margin. Care must be taken

not to trap the PTFE tape into the fit surface of the restoration during cementation, which may impede full seating of the restoration (Figs 8 and 9).

Protecting implant abutment screw heads during sealing of screw access channels

Screw-retained implant restorations have the advantage of retrievability for maintenance procedures such as replacement of components and hygiene purposes when compared to cement retained restorations.²¹

The potential for bacterial infiltration via the screw access channel has been shown in-vitro.^{22,23} A method of reducing this bacterial penetration is to seal the screw access channel. However, it is important to keep in mind the sealing restoration does not to compromise access to the abutment screw for future deconstruction of the implant restoration. Therefore, placement of a well-adapted passive material deep in the screw access channel over the abutment screw head minimises the risk of screw head damage during the retrieval procedure.

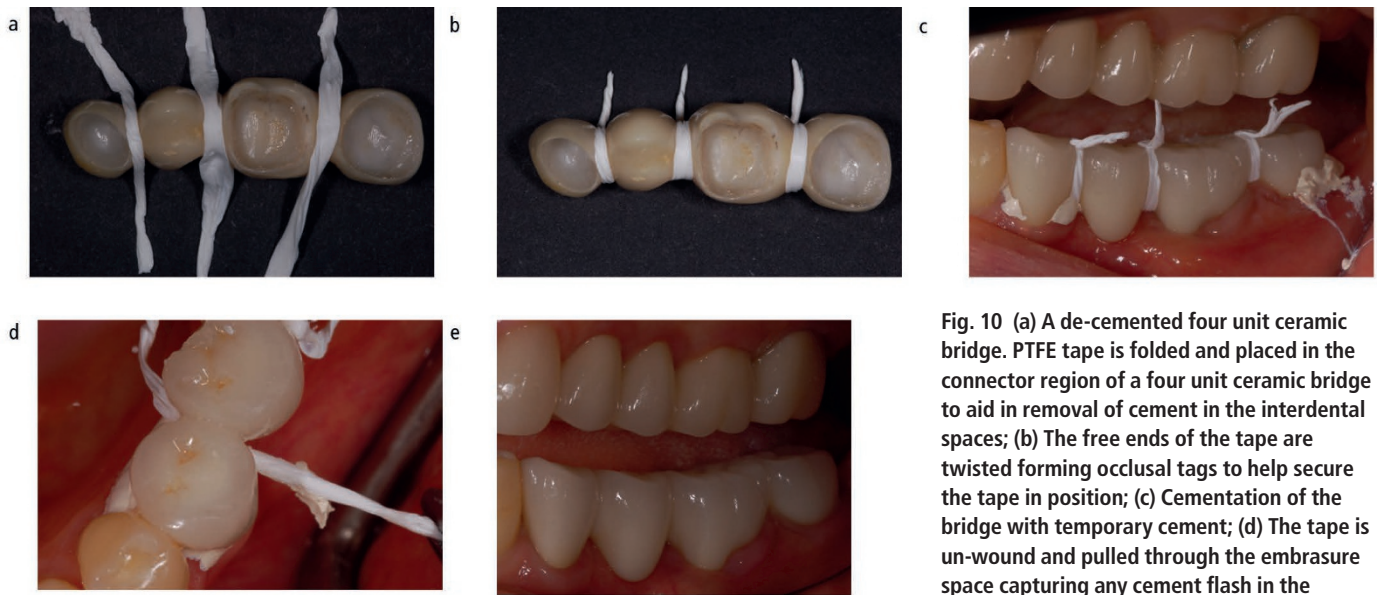


Fig. 10 (a) A de-cemented four unit ceramic bridge. PTFE tape is folded and placed in the connector region of a four unit ceramic bridge to aid in removal of cement in the interdental spaces; (b) The free ends of the tape are twisted forming occlusal tags to help secure the tape in position; (c) Cementation of the bridge with temporary cement; (d) The tape is un-wound and pulled through the embrasure space capturing any cement flash in the interdental area; (e) Ceramic bridge *in situ* after temporary cement removal

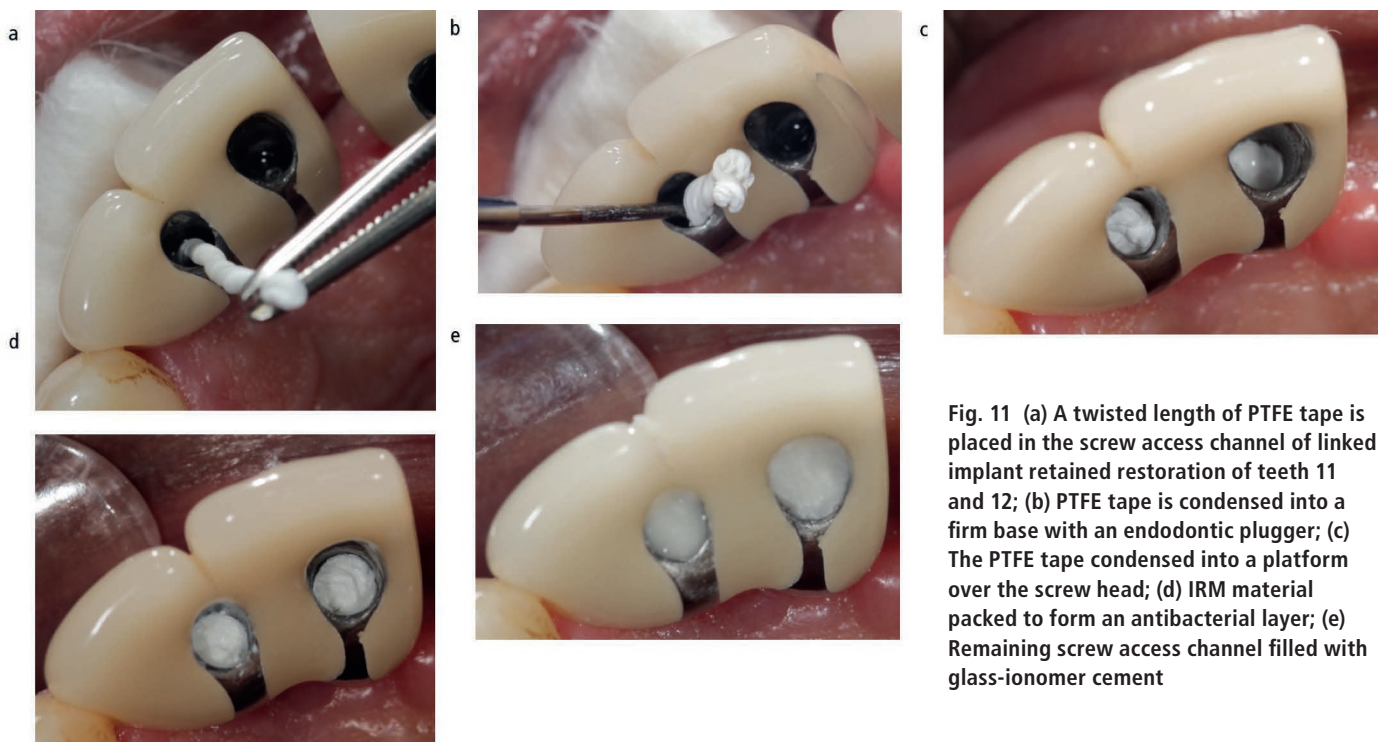


Fig. 11 (a) A twisted length of PTFE tape is placed in the screw access channel of linked implant retained restoration of teeth 11 and 12; (b) PTFE tape is condensed into a firm base with an endodontic plugger; (c) The PTFE tape condensed into a platform over the screw head; (d) IRM material packed to form an antibacterial layer; (e) Remaining screw access channel filled with glass-ionomer cement

Various materials have been proposed to protect screw heads during the restoration of screw access channels including; the use of cotton wool pellets, polyvinylsiloxane (PVS) material, gutta percha, acrylic resin or utilising custom-made cover screws.^{24,25} Cotton wool pellets are filamentous and have the ability to harbour bacteria; consequently they are associated with malodour during screw access. PVS material and gutta percha can prove difficult to remove and become

frustrating for the operator. Acrylic resin can flow into the screw head proving difficult to remove and risking damage to the screw head. The manufacture of lab-made custom cover screws is expensive and may not be readily available. The use of PTFE tape as a barrier between screw heads and restorative material has been suggested as a simple and cost effective alternative (Fig. 10).³

PTFE is non-filamentous which enables it to be removed whole more easily than cotton

wool; that is more likely to tear on withdrawal. The fibrous structure of cotton provides an ideal niche for bacteria to grow and cultivate when compared to PTFE. Furthermore, it cannot be compacted to the same density as PTFE and so may also provide dead space between the filaments where bacteria may thrive. As such it seems more practical to use PTFE for screw access holes to reduce bacterial presence within the chamber and for ease of retrievability.

As a barrier between the access cavity and the root canal system

Temporisation of a tooth undergoing multiple-visit root canal treatment requires a restoration that would ideally hermetically seal the access cavity, preventing ingress of saliva and bacteria. A barrier material below the temporary restoration prevents unwanted dental materials entering the root canal system during placement, with the additional benefit of being readily removable when required. Cotton wool or foam pellets have been previously described to aid in the removal of temporary endodontic dressings.²⁶ On re-accessing this reduces the risk of cutting tooth tissue, or in extreme cases perforation during the removal of temporary filling material.²⁷ The engagement of the bur into the barrier material can act as an indicator that the restoration has been breached.

The use of cotton wool, due its organic nature lends itself to bacterial uptake by wicking, also cotton fibers trapped in cavity walls can result in a compromised coronal seal and leakage into the disinfected root canal system.^{28,29} Indeed the apical migration of cotton wool fibres have been identified in apical granulomas with an associated inflammatory infiltrate.³⁰

PTFE tape can be used as an alternative to cotton wool or foam pellets below temporary endodontic restorations. It has been shown *in vitro* PTFE tape performs better at reducing bacterial contamination when used as a barrier under a 4 mm Cavit (3M ESPE) temporary restoration.²⁹ This can be attributed to the materials non-fibrous nature reducing the risk of bacterial uptake by wicking. When condensed, PTFE tape forms a firm platform, which may reduce the risk of marginal break down of temporary materials during occlusal loading by providing a more stable sub-structure (Fig. 11).

PTFE as a spacer for restorations

In the unfortunate event a tooth supporting a crown has fractured, it is possible to repair the fractured tooth abutment chair-side. Chan *et al.* described using PTFE tape to assist building up a direct core.³¹ After the contents of the crown are removed PTFE tape is adapted to the fit surface of the crown and it is filled with a suitable core material, the restoration is then seated on the remaining tooth abutment. The low surface energy of PTFE acts to prevent the auto-polymerising resin from adhering to the internal crown surface whilst also providing the cement relief space. This method can be useful in an emergency situation where an anterior crown may be required for aesthetic

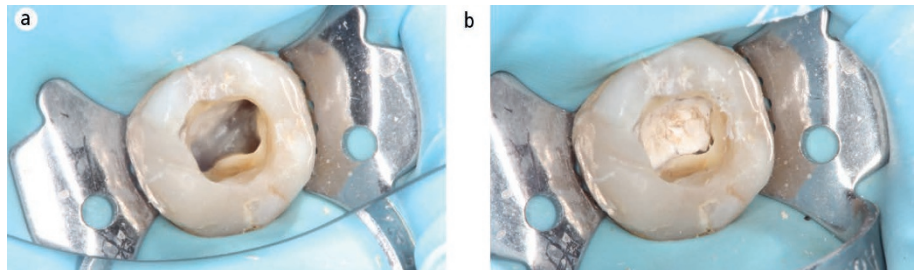


Fig. 12 (a) Endodontic access of tooth 16 which is to undergo multiple visit root canal treatment; (b) PTFE tape condensed over the access cavity of tooth 16 prior to restoration

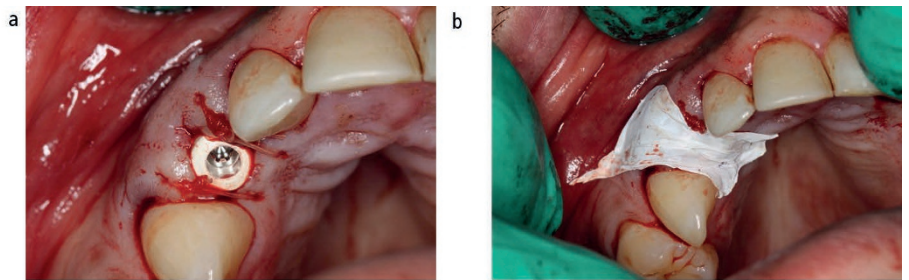


Fig. 13 (a) Healing abutment screw *in situ* following implant placement in tooth 13 space; (b) PTFE tape draped over the healing abutment prior to impression making for an Essix retainer. The PTFE tape acts to prevent the ingress of impression material into the screw access channel

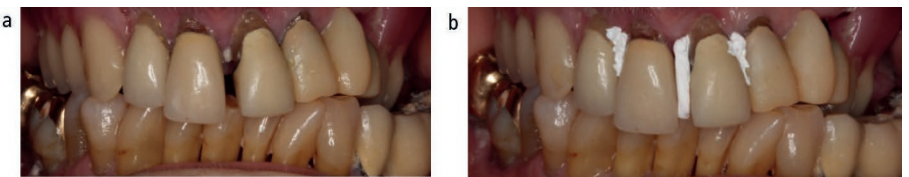


Fig. 14 (a) Teeth 12, 11, 21, 22 which are periodontally compromised and planned for extraction; (b) PTFE tape is packed into the embrasure space to prevent the interlocking of impression material and potential extraction of the mobile teeth

purposes. However, this technique requires a minimum of 2 mm of supra-gingival tooth structure and an intact finish line to allow correct seating of the crown.

The use of PTFE tape as a spacer material can also be applied to assist in obtaining an even cement film thickness during cementation of implant crowns. Chandur P.K *et al.*⁵ have suggested adapting PTFE tape to the fit surface of an implant crown and creating a copy abutment using a bite registration material. The crowns fit surface is thoroughly cleaned and filled with cement, the copy abutment is then inserted to allow even distribution of cement on the fit surface prior to definitive cementation. This method ensures an evenly distributed cement film thickness with minimal clean up after seating, however requires the use of a slow setting cement.

Block-out material for impression making

The control of impression material is important in preventing the ingress of material in unwanted areas. This is pertinent in regions where there are hard or soft tissue defects as a result of vertical bone loss from missing teeth or periodontal disease. The screw access channel of implant components is also an area in which impression material may occlude.

Areas where the impression material may inter-lock such as deep gingival embrasure spaces can present a challenge when recording impressions.³² Polymerised impression material engaged in the undercut of a bridge pontic or large gingival embrasure poses the risks of causing trauma and an unpleasant experience for the patient during removal, it

Table 2 Advantages and disadvantages of PTFE tape

Feature	Advantage	Disadvantage
Variable thickness	Thinner than a clear plastic matrix, therefore it will not interfere with the seating of an extra-coronal restoration or a tooth mould index.	Requires a learning curve when handling and applying interproximally in the presence of tight tooth contacts.
Non-stick	The material is easily removed and does not leave a residue on the surface it contacts.	If not secured, the tape can be easily distorted or displaced by the high volume suction.
Inert	Remains unchanged under restorations or with the use of dental acids or solvents.	If disposed in the water waste system can accumulate and cause blockage of pipes, owing to its non-biodegradable nature. ³⁶
	Its non-flameouts structure ensures restorative materials are not contaminated.	
Pliable	Can be stretched or condensed with minimal loss to its structural integrity.	Performs poorly under cyclic and load-bearing situations if used in thin sections. This may result in the tape becoming porous and eventually tearing.
	This allows the clinician to drape it over a tooth for aesthetic restorations, or place it into a cavity to form a base under a temporary restoration.	

may also prevent access to implant screws by obstructing the screw access channel (Fig. 12).

A method to avoid such a situation is to block-out undesirable voids by using pliable and removable materials, some include: ribbon wax, polymer-based materials, 'interdental wedges', or temporary fillings.^{32,33} Although inexpensive, these methods can be time consuming and require time for removal of the residual material post impression. PTFE tape can be easily compacted to block out undercuts prior to impression making, with the advantage of straightforward removal without leaving residual material (Fig. 13). This method is only successful where there is a defined undercut allowing compaction of the tape; broad bony undercuts may be better blocked-out with wax as PTFE tape will be easily displaced here. This technique can also be implemented where an impression is required of patient with fixed orthodontic brackets, for example, for the construction of a mouth guard.

Trial seating of extra-coronal restorations

Prior to cementation of a restoration, performing a try-in to ensure optimal margins and both interocclusal and interproximal contact is considered good practice.³⁴ This provides an opportunity for the patient to see the restoration and the clinician to make any necessary adjustments preceding formal cementation.

The try-in stage can be challenging, particularly if the intended restorations are small or there are multiple crowns for cementation. Where preparations are especially retentive try-in can result in frictional binding, making subsequent removal of the restoration difficult prior to cementing definitively. This may be more relevant in situations where parallel walls are present or where delicate ceramic

restorations can potentially fracture if unfavourable removal forces are applied.

Various removal procedures have been proposed to overcome the difficulty in removing a restoration following trial insertion, including the use of flexible adhesive sticks, thermoplastic resin, a locator handle created on the restoration and also the use of an explorer or straight probe.³⁵

The use of PTFE tape to retrieve a well-fitting onlay has been described by Geissenberg *et al.*³⁵ By adapting PTFE tape onto the fit surface prior to trial seating, the clinician can safely retrieve the restoration with minimal risk of damage by drawing on the free ends of the PTFE tape and pulling the restoration free.

The tape can also function as a 'fit checker' to inspect the fit surface of an indirect restoration for 'dark spots' following trial insertion, indicating an area of limited space or a premature contact and allowing for selective adjustment of localised spots.²

Conclusion

PTFE tape has some advantages over commonly used dental materials and may prove beneficial in certain clinical situations. These include and are not limited to: a tooth separation medium; protecting endodontic access cavities and screw access channels; impression and restoration recovery; assisting in cement clean up; and as a cement lute spacer. As with any dental material it is imperative the clinician makes a judgment of the intended use of the material and whether benefits outweigh the risk. Table 2 highlights some of the advantages and disadvantages of using PTFE tape to assist in dental procedures.

PTFE tape provides clinicians with a simple, readily available and cost effective material in their armamentarium, which can easily be incorporated into any dental practice. The applications

illustrated are not exclusive to restorative procedures and the versatility of the material allows it to be applied into other areas of clinical dentistry.

1. Bottino M C, Thomas V, Schmidt G, Vohra Y K, Chu T M, Kowolik M J, Janowski G M. Recent advances in the development of GTR/GBR membranes for periodontal regeneration: a materials perspective. *Dent Mater* 2012; **28**: 703–721.
2. Stean H. PTFE tape: a versatile material in restorative dentistry. *Dent Update* 1993; **20**: 146–148.
3. Moráquez O D, Belsler U C. The use of polytetrafluoroethylene tape for the management of screw access channels in implant-supported prostheses. *J Prosthet Dent* 2010; **103**: 189–191.
4. Ratner B D, Hoffman A S, Schoen F J, Lemons J E. *Biomaterials science: an introduction to materials in medicine*. 3rd ed. pp 92–103. Academic Press, 2013.
5. Graffte K. Fluoropolymers: Fitting the Bill for Medical Applications. *Medical Device & Diagnostic Industry Magazine*. 2005. Available online at <http://www.mddionline.com/article/fluoropolymers-fitting-bill-medical-applications> (accessed January 2017).
6. Hongxiang T. Overview of the development of the fluoropolymer industry. *Appl Sci* 2012; **2**: 496–512.
7. Wadhvani C P K (ed). *Cementation in dental implantology: An evidence-based guide*. 1st ed. pp 148–150. Berlin Heidelberg: Springer-Verlag, 2015.
8. Kelleher M G, Bomfim D I, Austin R S. Biologically based restorative management of tooth wear. *Int J Dent* 2012; **742509**.
9. LeSage B P. Aesthetic anterior composite restorations: a guide to direct placement. *Dent Clin North Am* 2007; **51**: 359–378, viii.
10. Chandra S, Chandra S, Chandra G. *Textbook of operative dentistry (with MCQs)*. 1st ed. p 141. Jaypee Brothers Publishers, 2008.
11. Brown D E. Using plumber's teflon tape to enhance bonding procedures. *Dent Today* 2002; **21**: 76–78, 80–1.
12. Dunn W J, Davis J T, Casey J A. Polytetrafluoroethylene (PTFE) tape as a matrix in operative dentistry. *Oper Dent* 2004; **29**: 470–472.
13. Daoudi M, Radford J. Use of a matrix to form directly applied resin composite to restore worn anterior teeth. *Dent Update* 2001; **28**: 512–514.
14. Mitchell C A, Pintado M R, Geary L, Douglas W H. Retention of adhesive cement on the tooth surface after crown cementation. *J Prosthet Dent* 1999; **81**: 668–677.
15. Wilson T G Jr. The positive relationship between excess cement and peri-implant disease: a prospective clinical endoscopic study. *Periodontol* 2009; **80**: 1388–1392.
16. Alani A, Bishop K. Peri-implantitis. Part 2: Prevention and maintenance of peri-implant health. *Br Dent J* 2014; **217**: 289–297.
17. Wadhvani C, Piñeyro A. Technique for controlling the cement for an implant crown. *J Prosthet Dent* 2009; **102**: 57–58.

18. Yuzbasioglu E. A modified technique for extraoral cementation of implant retained restorations for preventing excess cement around the margins. *J Adv Prosthodont* 2014; **6**: 146–149.
19. Bennani V, Schwass D, Chandler N. Gingival retraction techniques for implants *versus* teeth: current status. *J Am Dent Assoc* 2008; **139**: 1354–1363.
20. Hess T A. A technique to eliminate subgingival cement adhesion to implant abutments by using polytetrafluoroethylene tape. *J Prosthet Dent* 2014; **112**: 365–368.
21. Shadid R, Sadaqa N. A comparison between screw and cement-retained implant prostheses. A literature review. *J Oral Implantol* 2012; **38**: 298–307.
22. Quirynen M, Bollen C M, Eysen L, Van Steenberghe D. Microbial penetration along the implant components of the Brånemark system. An *in vitro* study. *Clin Oral Implants Res* 1994; **5**: 239–244.
23. Park S D, Lee Y, Kim Y L, Yu S H, Bae J M, Cho H W. Microleakage of different sealing materials in access holes of internal connection implant systems. *J Prosthet Dent* 2012; **108**: 173–180.
24. Adrian E D, Krantz W A, Ivanhoe J R, Turner K A. A silicone obturator for the access canal in an implant-retained fixed prosthesis. *J Prosthet Dent* 1991; **65**: 597.
25. Howell J C Jr, Caldwell W D. Custom-made cover screws to fit fixed detachable implant prosthesis access openings. *J Prosthet Dent* 1997; **78**: 209–211.
26. Messer H H, Wilson P R. *Preparation for restoration and temporization. Principles and practice of endodontics*. 2nd ed. pp 260–276. Philadelphia, USA: W B. Saunders Co, 1996.
27. Naoum, H J, Chandler N P. Temporization for endodontics. *Int Endod J* 2002; **35**: 964–978.
28. Paranjpe A, Jain S, Alibhai K J, Wadhvani C P, Darveau R P, Johnson J D. *In vitro* microbiologic evaluation of PTFE and cotton as spacer materials. *Quintessence Int* 2012; **43**: 703–707.
29. Newcomb B E, Clark S J, Eleazer P D. Degradation of the sealing properties of a zinc oxide-calcium sulfate-based temporary filling material by entrapped cotton fibers. *J Endod* 2001; **27**: 789–790.
30. Nair P N. On the causes of persistent apical periodontitis: a review. *Int Endod J* 2006; **39**: 249–281.
31. Chan DC. Technique for repair of multiple abutment teeth under preexisting crowns. *J Prosthet Dent* 2003; **89**: 91–92.
32. Hummert T W, Kaiser D A. Block-out technique for impressions of teeth with increased open gingival embrasures. *J Prosthet Dent* 1999; **82**: 100–102.
33. Monzavi A, Asadi G. Use of irreversible hydrocolloid to blockout interproximal spaces for an easy impression taking. *J Dent* 2009; **6**: 206–208.
34. Wassell R W, Barker D, Steele J G. Crowns and other extra-coronal restorations: Try-in and cementation of crowns. *Br Dent J* 2002; **193**: 17–28.
35. Geissberger M J, Hagge M S, Milani J E, Leknius C. Simplified clinical procedure for fitting and removing inlays/onlays prior to cementation. *J Prosthet Dent* 2002; **87**: 395–398.
36. Clague-Moore J. Dental tape - a cautionary tale. *Br Dent J* 2001; **191**: 227.