

Clinical Results

# Protemp™ Plus Protemp™ Crown

Temporization Material

You + 3M ESPE =

*Learning that goes both ways*

# Expertise™



**3M ESPE**

Dental Products  
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**3M ESPE**

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### Protemp™ Crown

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## Introduction

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We at 3M ESPE – the worldwide leader in temporization solutions – focus our innovation and expertise on products that meet the evolving needs of dental professionals, help to simplify their daily practice and save their valuable time.

With the introduction of two top-notch products since 2007, we continue to set industry standards by offering revolutionary technologies and uncompromising solutions in the field of temporization. Both products join a family of high-quality, reliable temporization materials.

The development of Protemp™ Crown Temporization Material was based on the innovative idea of providing a temporary crown which is preformed and made of flexible, light-curable material. The use of this product should help dentists save time; its easy handling is another convincing plus.

Protemp Crown material now enables dental professionals to quickly and easily fabricate outstandingly strong and esthetic posterior single-unit temporaries while no impression or matrix is needed.

With Protemp™ Plus Temporization Material, we have set up another milestone in temporary crown and bridge materials. We have applied our expertise in nanotechnology to create the first bis-acrylic material with a new generation of sophisticated fillers for the fabrication of multiple-unit temporaries. With many unparalleled features, Protemp Plus material is unique in the market and was developed to satisfy even the most demanding temporization requirements. Protemp Plus temporization material provides record-breaking toughness and natural-looking esthetics with improved color stability, as well as easy handling without the need for polishing or glazing.

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Since their introduction on the market, both products have been approved as also being particularly well suited for long-term temporization as well as for the implant procedure.

This brochure combines the results of global application tests and a collection of clinical studies on both Protemp™ Crown and Protemp™ Plus Temporization Material.

We are very happy that, with our Protemp™ Temporization Family, we can offer you products that achieve outstanding and convincing clinical results.

With kind regards,



Dr. Rainer Guggenberger  
Corporate Scientist

3M ESPE, Seefeld/St. Paul, June 2009



Protemp™ Plus

Temporization Material

## Results from 3M ESPE field evaluation

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### Overall satisfaction with Protemp™ Plus Temporization Material

Like all new 3M™ ESPE™ products, Protemp Plus temporization material was tested in dental practices before market introduction. Carried out in 2008, the field test involved more than 200 dental practices in Germany, Italy, Switzerland, and the UK. During the 8 week test period approximately 4400 temporary restorations were fabricated and placed.

Many of Protemp Plus temporization material's attributes were highly rated by evaluators leading to an overall satisfaction level of more than 90%.

In addition, 95 % of all participating dentists would recommend Protemp Plus material to their colleagues.



#### Overall satisfaction with Protemp™ Plus Temporization Material.

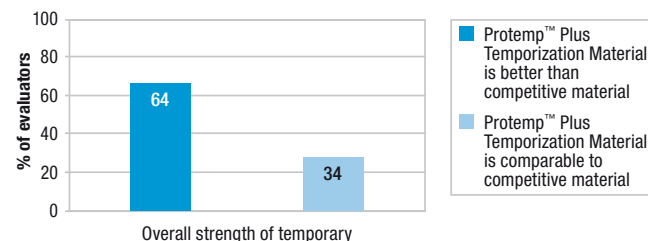
(Top 2 box results on a 5 scale from "excellent" to "very poor")

Source: 3M ESPE field evaluation 2008

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### Reliable overall strength of Protemp™ Plus temporaries

64 % of the test participants rated the overall strength of Protemp Plus temporaries to be better than the strength of temporaries made with their currently used temporization material.



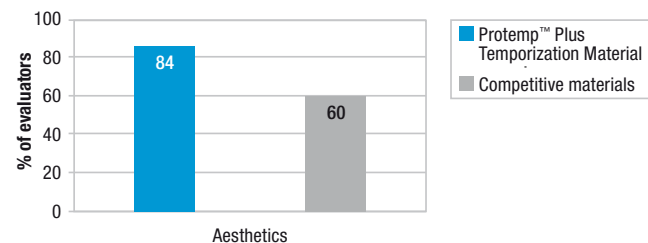
#### Rating of the overall strength of Protemp™ Plus Material in comparison to currently used temporization materials.

(Overall strength of Protemp™ Plus Material)

Source: 3M ESPE field evaluation 2008

### Protemp Plus temporaries show outstanding esthetic attributes

In comparison with competitive materials, 84 % of the participating dentists gave "excellent" or "very good" ratings for the esthetic attributes of Protemp Plus temporaries – thus agreeing with their patients who perceive Protemp Plus temporaries to be highly esthetic and natural-looking.



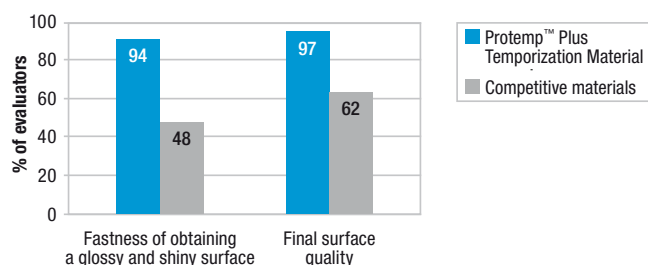
#### Ratings for esthetic attributes of Protemp™ Plus Temporization Material and competitive temporary materials currently used by evaluators.

(Top 2 box results on a 5 scale from "excellent" to "very poor")

Source: 3M ESPE field evaluation 2008

## Enhanced surface quality of Protemp™ Plus Temporization Material

Asked for the fastness of achieving a glossy and shiny surface with Protemp Plus temporization material, 94 % of the testers gave “excellent” or “very good” ratings. 97 % found the final surface quality of Protemp Plus material to be “excellent” or “very good”.



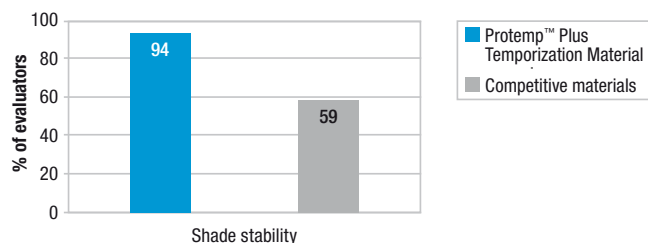
**Fastness of obtaining a glossy and shiny surface, final surface quality.**

(Top 2 box results on a 5 scale from “excellent” to “very poor”)

Source: 3M ESPE field evaluation 2008

## Protemp Plus temporaries show higher color stability

Compared with the evaluators’ currently used competitive temporization materials, the shade stability of Protemp Plus material was assessed as considerably higher. 94 % of the test dentists gave “excellent” or “very good” ratings.



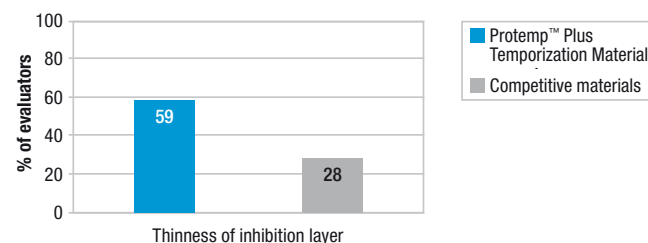
**Ratings for shade stability of Protemp™ Plus Temporization Material and competitive temporary materials currently used by evaluators.**

(Top 2 box results on a 5 scale from “excellent” to “very poor”)

Source: 3M ESPE field evaluation 2008

## Less inhibition layer of Protemp™ Plus Temporization Material

Compared to competitive bis-acrylic materials that are currently being used, Protemp Plus temporization material shows tangibly less inhibition layer and therefore provides a faster and easier handling and procedure. This earned high credits from the participating dentists: 59 % gave “excellent” or “very good” ratings – twice as many as for competitive materials.



**Ratings for thinness of inhibition layer of Protemp™ Plus Temporization Material and competitive temporary materials currently used by evaluators.**

(Top 2 box results on a 5 scale from “excellent” to “very poor”)

Source: 3M ESPE field evaluation 2008



**Protemp™ Plus Temporization Material**

## Fracture performance of provisional crown and bridge restoration materials

Published by: M. ROSENTRITT, R. LANG, M. BEHR and G. HANDEL, Regensburg University Medical Center, Germany  
PEF 2008, London, UK, # 0062

**Objectives:** High strength of modern provisional materials is important for extending the time for clinical application. It was the aim of this study to determine fracture resistance and fracture toughness of different provisional restorative materials including an experimental product.

**Methods:** In this *in vitro* study fracture strength of 3-unit bridges of provisional crown and bridge materials was determined. Identical alloy dyes (Biosil®, DeguDent) were fixed in resin at a distance of 10 mm simulating a posterior gap. An artificial periodontium was provided with Impregum™ Polyether Impression Material (3M ESPE). All bridges were bonded with RelyX™ Temp NE Temporary Cement (3M ESPE). Ten samples of each group were stored in aqua dist. for 14 days and subsequently submitted to thermal-cycling and mechanical-loading (TCML: 50 N, 480,000 loadings; 1200 × 5°/55° C). Occlusal wear was determined with 3D scanning. Ten samples of each material were stored for 24 hours in aqua dist. as a control. All specimens were loaded to fracture (Zwick; v = 1 mm/min). Fracture patterns were determined optically. Independently fracture toughness  $K_{Ic}$  was determined (n = 10). Medians and 25 % / 75 % percentiles were calculated. Statistics: Mann-Whitney-U-Test ( $\alpha = 0.05$ ).

### Results:

Materials	Median (25%/75 %)		
	Fracture Force [N] (24hrs H <sub>2</sub> O storage)	Fracture Force [N] (14 days H <sub>2</sub> O storage + TCML)	$K_{Ic}$ [MPa·m <sup>1/2</sup> ]
Luxatemp® Fluorescence (DMG)	1006 (749/1237)	875 (771/1006)	0.89 (0.84/0.95)
Integrity™ Fluorescence (Dentsply)	897 (630/1159)	798 (718/897)	0.94 (0.80/0.99)
Structur Premium (Voco)	946 (858/1130)	820 (621/946)	1.07 (0.98/1.39)
Protemp™ Plus (3M ESPE)	1133 (909/1310)	920 (852/1133)	2.18 (1.92/2.40)
Acrytemp (Zhermack)	740 (672/787)	(total failure)	1.66 (1.51/1.71)

**Conclusion:** The tested materials lose about 11 – 19 % of their fracture strength due to TCML. One material even failed completely during aging. Among the surviving materials experimental Protemp™ Plus Temporization Material showed the highest fracture resistance after TCML as well as highest fracture toughness and may be therefore considered for long-term temporization.

### 3M ESPE Summary

**Aim of the study:** To determine fracture resistance of 3-unit bridges in a thermocycling-mechanical loading (TCML) *in vitro* set up simulating 2 years of clinical use as well as in K<sub>Ic</sub> fracture toughness test.

**Results of the study:** Protemp Plus temporization material showed the highest fracture resistance before and after TCML and the highest fracture toughness ( $K_{Ic}$ ) compared to leading provisional crown and bridge materials. It can be recommended for long-term temporization.

## Fracture resistance of temporary crown and bridge materials after chewing simulation

Published by: S. HADER, U. HOHEISEL, R. HECHT, 3M ESPE, Seefeld, Germany  
IADR 2008, Toronto, Canada, # 1047

**Objectives:** To compare flexural strength (FS) and number of fractures (NF) of one novel and 5 established crown and bridge materials before and after thermocycling and mechanical loading (TCML) in a 2-year simulation.

**Methods:** 3-unit bridges were fabricated of each material and cemented on Co-Cr alloy abutments with RelyX™ Temp NE Temporary Cement (3M ESPE). Abutments were fixed in a PMMA block where each root area was covered with a 0.5 mm polyether (Permadyne™ Garant™ Polyether Impression Material) layer to imitate the periodontium. Each material had ten bridges tested before (waterstorage at 36° C for 14d) and after



Set-up of a TCML unit.

chewing simulation (waterstorage at 36° C for 4d followed by TCML). TCML (3,000 × 5° C/ 55° C; 480,000 × 100 N) was performed to simulate a 2-year clinical simulation using a stainless steel antagonist (diameter: 3 mm). Finally all bridges were loaded until fracture using a Zwick universal testing machine (Zwick Z010; crosshead speed: 1 mm/min; fracture detection: 50 % of Fmax). Descriptive statistics were performed. Results are summarized in the table.

### Results:

Material	FS before TCML [N] median (25 % / 75 %)	FS after TCML [N] median (25 % / 75 %)	Difference in FS [N] before and after TCML median	NF (n) before end of TCML
Protemp™ Plus (3M ESPE)	1,371 (1,198/1,575)	1,288 (1,026/1,575)	83	0
Protemp™ 3 Garant™ (3M ESPE)	1,299 (1,198/1,525)	981 (770/1,525)	318	1
Structur Premium (Voco)	1,246 (1,127/1,468)	634 (521/1,062)	612	4
Luxatemp® Fluorescence (DMG)	1,352 (1,197/ 1,441)	847 (769/1,019)	505	4
Integrity™ Fluorescence (Dentsply)	1,337 (1,097/1,643)	1,076 (620/1643)	261	1
Kanitemp Royal (Kaniedenta)	1,268 (980/1,391)	898 (632/1,179)	370	1

Protemp™ Plus Temporization Material showed the highest value of flexural strength (FS) and fracture resistance (NF) compared to the other materials tested after a TCML simulation of 2 years *in vitro*. No fracture occurred after TCML.

**Conclusion:** These results are an indicator that Protemp Plus temporization material has improved mechanical properties suitable for long-term temporization.

### 3M ESPE Summary

**Aim of the study:** To compare fracture resistance of Protemp Plus material and other bis-acrylic materials before and after an *in vitro* 2-year chewing simulation with doubled forces (100N) being applied.

**Results of the study:** Protemp Plus material showed the highest fracture resistance after the 2-year chewing simulation under the load of 100 N and can therefore be considered for long-term temporization.



## Selected mechanical properties of temporary crown and bridge materials

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Published by: V. BABIC, R. PERRY and G. KUGEL, Tufts University, Boston, MA, USA

AADR 2008, Toronto, Canada, # 0371

**Objective:** This study examined an experimental provisional material and compares selected mechanical properties of this material with five other conventionally used provisional materials.

**Methods:** Six groups (N = 6) were selected to undergo a three-point flexural test comparable to ISO4049 to determine flexural strength, fracture work and deflection using a Zwick materials testing machine. Compressive strength was measured according to standard DIN 53454. Impact strength was measured according to Charpy (ISO 179-1). The materials used were Structur Premium (Voco), Protemp™ Plus Temporization Material (3M ESPE), Acrytemp (Zhermack), Kanitemp Royal (Kaniedenta), Integrity™ Fluorescence (Dentsply) and Luxatemp® Fluorescence (DMG).

**Results:** Data was analyzed using a one way ANOVA with a Fisher test and a confidence interval of 95 %. Summary of results and mean values including standard deviations (in brackets) were calculated.

Mechanical property	Summary of results
Flexural strength (Mpa)	Protemp™ Plus significantly better than Acrytemp, Integrity™ Fluorescence, Luxatemp® Fluorescence
Deflection (mm)	Protemp™ Plus significantly better than Acrytemp, Integrity™ Fluorescence, Luxatemp® Fluorescence, Structur Premium
Fracture work (KJ/m²)	Protemp™ Plus significantly better than Acrytemp, Integrity™ Fluorescence, Luxatemp® Fluorescence, Structur Premium
Impact strength (KJ/m²)	Protemp™ Plus significantly better than Acrytemp, Integrity™ Fluorescence, Luxatemp® Fluorescence, Structur Premium
Compressive strength (Mpa)	Protemp™ Plus significantly better than Acrytemp, Integrity™ Fluorescence, Luxatemp® Fluorescence, Structur Premium

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Material	Flexural strength [Mpa]	Deflection [mm]	Fracture work [KJ/m²]	Impact strength [KJ/m²]	Compressive strength [Mpa]
Structur Premium	113.0 [4.4]	1.04 [0.06]	8.64 [0.94]	8.5 [1.2]	340.8 [17.0]
Protemp™ Plus	91.4 [3.4]	1.43 [0.12]	10.74 [1.58]	15.7 [4.5]	395.6 [29.0]
Acrytemp	70.0 [6.0]	1.25 [0.10]	6.77 [1.03]	7.0 [1.6]	257.5 [20.2]
Kanitemp Royal	72.5 [4.2]	1.18 [0.06]	6.54 [0.62]	7.6 [1.4]	250.1 [17.7]
Integrity™ Fluorescence	72.5 [3.6]	0.97 [0.10]	5.13 [0.83]	8.8 [2.6]	283.0 [19.2]
Luxatemp® Fluorescence	74.4 [3.6]	1.06 [0.10]	5.94 [1.04]	7.3 [1.3]	281.5 [ 9.6]

**Conclusion:** According to the results of this study, Protemp™ Plus Temporization Material shows significantly better values for deflection, fracture work, compressive strength and impact strength when compared to each of the other materials.

(Partially sponsored by 3M ESPE)

### 3M ESPE Summary

**Aim of the study:** To compare *in vitro* mechanical properties of Protemp Plus temporization material with established temporary crown and bridge materials.

**Results of the study:** Protemp Plus material shows significantly better mechanical properties.

## Atomic Force Microscopy (AFM) of temporary crown and bridge materials

Published by: L. BERGMEIER<sup>1</sup>, S. HADER<sup>1</sup>, U. HOHEISEL<sup>1</sup>, and V. JONES<sup>2</sup>,  
<sup>1</sup>3M ESPE AG, Seefeld, Germany, <sup>2</sup>3M, St. Paul, MN, USA  
 IADR 2008, Toronto, Canada, # 1046

**Objectives:** To compare surface topography of four cured, unpolished temporary crown and bridge materials using AFM imaging.

**Methods:** Tapping mode AFM scans of fully cured, unpolished material samples were performed. (Digital Instruments Dimension 50,000 SPM) using Olympus OTESP single crystal silicon levers with a force constant of ~40N/M as a probe. Setpoint: 75% of original free space amplitude (2.0V). Image scan size: 10 × 10 μm. Vertical scale: +/- 750 nm. Roughness values were measured using Veeco Vision software (version 3.5).

**Results:** Average roughness (Ra in nm) was: Protemp™ Plus Temporization Material: 22.96; Luxatemp® Fluorescence: 237.9; Structur Premium: 131.8; Kanitemp Royal: 154.93. RMS roughness values (Rq in nm) were as follows: Protemp Plus material: 29.9; Luxatemp Fluorescence: 301.8; Structur Premium: 165.5; Kanitemp Royal: 208.5. Average maximum height values were (Rz in μm): Protemp Plus material: 0.26; Luxatemp Fluorescence: 1.77; Structur Premium: 1.2; Kanitemp Royal: 2.03.

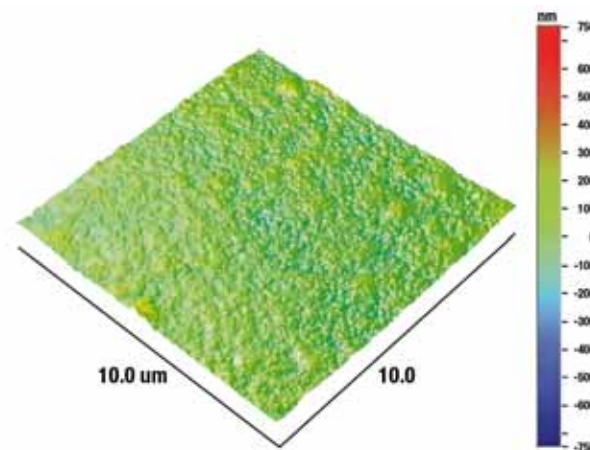
**Conclusion:** Unpolished Protemp Plus temporization material is significantly smoother than the other materials tested, making an extra polishing step unnecessary.

### 3M ESPE Summary

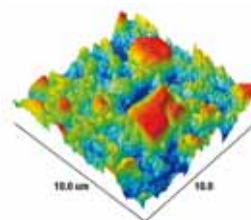
**Aim of the study:** To compare surface properties of Protemp Plus temporization material with three other leading crown and bridge materials via AFM scan.

**Results of the study:** Protemp Plus material has significantly smoother surface properties – even without polishing.

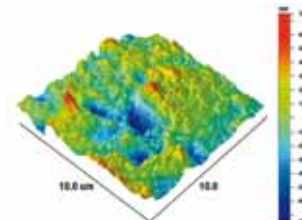
Protemp™ Plus Temporization Material



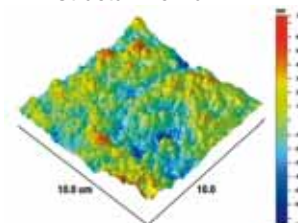
Luxatemp® Fluorescence



Kanitemp Royal



Structur Premium



## Morphological characterization of a new temporary crown and bridge material

Published by: A. SEZINANDO, University of Lisbon, Lisboa, Portugal, and J. PERDIGAO, University of Minnesota, MN, USA  
IADR 2009, Miami, Florida, USA, # 1061

**Objectives:** To characterize the ultra-morphology (AFM, FESEM) and surface characteristics (Profilometry) of four bis-acryl composite resins for provisional fixed restorations.

**Methods:** Materials: (1) Integrity™ Fluorescence (Dentsply); (2) Luxatemp® Fluorescence (DMG); (3) Protemp™ Plus Temporization Material (3M ESPE); and (4) Structur Premium (Voco). AFM/FESEM – three unpolished disks from each material were fabricated; three AFM readings were taken randomly from each specimen, same magnification. The specimens were coated with Au-Pd and observed under a FESEM (X5,000 – X50,000). Nanoprobe Profilometer – three unpolished and three polished (Sof-Lex™ XT, 3M ESPE) specimens from each material were analyzed with the Nano-probe Profilometer in three different areas of each specimen. Separate statistical analyses (ANOVA, Duncan's,  $p < 0.05$ ) for polished/unpolished specimens were computed with SPSS14.0 (SPSS Inc).

**Results:** AFM – Surface topography of Protemp Plus material was distinct from the other materials. Smooth surfaces were observed consistently across the Protemp Plus material specimens as opposed to the irregular topography for the other materials; FESEM – The morphology of Integrity Fluorescence and Luxatemp Fluorescence was similar, showing filler particles up to  $3\mu\text{m}$ -wide with empty areas resulting from detachment of filler particles and gaps at the interface between the particle and the surrounding matrix. For Structur Premium, the biggest particle size was under  $2\mu\text{m}$ , with areas displaying clustered microfiller particles. For Protemp Plus material, the particle size resembled that of a nanofilled composite ( $20\text{--}30\text{ nm}$ ), with dispersed spherical particles in the range of  $40\text{--}50\text{ nm}$ .

Profilometry (nm) – For polished specimens, Protemp Plus temporization material resulted in the lowest roughness ( $0.86 \times 10^3$ ) which was significantly lower than the other materials (Integrity Fluorescence –  $1.60 \times 10^3$ ; Luxatemp Fluorescence –  $1.36 \times 10^3$ ; Structur Premium –  $1.90 \times 10^3$ ).

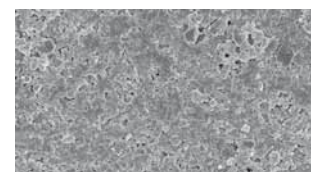
The pairs Luxatemp® Fluorescence/Integrity™ Fluorescence and Integrity Fluorescence/Structur Premium ranked in the same subset. For unpolished specimens, Integrity Fluorescence ( $7.51 \times 10^3$ ) resulted in significantly greater roughness than the other materials. Protemp™ Plus Temporization Material resulted in the lowest roughness ( $1.27 \times 10^3$ ).

**Conclusion:** Protemp Plus material resulted in smoother morphology than the other 3 materials.

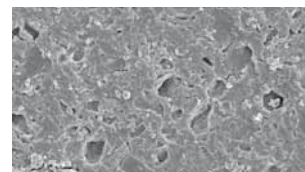
(supported by 3M ESPE)



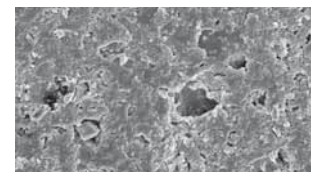
Protemp™ Plus Temporization Material



Structur Premium



Integrity™ Fluorescence



Luxatemp® Fluorescence

### 3M ESPE Summary

**Aim of the study:** To compare surface properties of leading provisional crown and bridge materials including Protemp Plus temporization material with different methods (Profilometer, AFM, FESEM).

**Results of the study:** Protemp Plus temporization material has a smoother surface than other provisional crown and bridge materials without polishing.

## Color stability of composite based temporary crown and bridge materials

Published by: S. HADER, U. HOHEISEL, R. HECHT and C. THALACKER,  
3M ESPE AG, Seefeld, Germany  
PEF 2008, London, UK, # 0392

**Objectives:** To compare color stability of composite based crown and bridge materials with regard to exogenic staining against coffee and red wine.

**Methods:** Test samples (diameter: 20 mm, height: 3.5 mm) for coffee test (n=3) and red wine test (n=6) were fabricated of each material and cured for 1 hour against glass plates at room temperature. The inhibition layer was removed with alcohol. Cielab L\*, a\* and b\* values were determined by using Hunterlab Labscan Spectrocolorimeter (aperture: 12 mm; measuring field: 12 mm). Then the test samples were immersed in coffee (extract of 200 g coffee with 1.000 ml boiling water) and red wine for 72 hours at 36° C. After removal test samples were rinsed with water and cleaned with a toothbrush for 30 seconds on each side. Cielab L\*, a\* and b\* values were determined again and the discoloration dE\* was calculated. Descriptive statistics were performed by using one way ANOVA with a Fisher test and a confidence interval of 95 %. Results including standard deviations (STD) are summarized in the table below.











### Results:

Material	Red wine dE*: (STD)	Coffee dE*: (STD)
Protemp™ Plus	3.13 (0.27) <sup>a</sup>	3.70 (0.28) <sup>a</sup>
Structur Premium	5.92 (0.42) <sup>d</sup>	5.29 (0.67) <sup>b</sup>
Luxatemp® Fluorescence	3.73 (0.35) <sup>b</sup>	7.99 (0.53) <sup>c</sup>
Integrity™ Fluorescence	3.73 (0.27) <sup>b</sup>	7.61 (0.42) <sup>c,d</sup>
Kanitemp Royal	5.26 (0.23) <sup>c</sup>	9.11 (0.69) <sup>d</sup>

Same letter indicates no significant difference within the same column.

Protemp™ Plus Temporization Material showed the best color stability over time in this *in vitro* test set up with coffee or red wine staining solutions.

**Conclusion:** These results are an indicator that Protemp™ Plus Temporization Material with its improved surface properties has significantly better color stability than other composite based crown and bridge materials and will be able to meet increasing esthetical customer needs.

	Before	After
Protemp™ Plus		
Luxatemp® Fluorescence		
Integrity™ Fluorescence		
Kanitemp Royal		
Structur Premium		

Coffee test: test specimen 3 days immersed in coffee at 36° C.  
Source: 3M ESPE internal data

### 3M ESPE Summary

**Aim of the study:** To compare stain resistance of leading temporary crown and bridge materials against coffee and red wine.

**Results of the study:** Protemp Plus temporization material demonstrates significantly improved stain resistance in this *in vitro* set-up.

## Smear layers thickness of temporary materials against air and VPS

Published by: Q.N.T. BUI, L. TRAN, R. PERRY, G. KUGEL, and P. STARK,  
Tufts University, Boston, MA, USA  
IADR 2009, Miami, Florida, USA # 3279

**Objective:** Determine the thickness of the residual smear layers of auto-mixed temporary materials against air and impression materials.

**Methods:** Twenty-four groups (N = 6) were selected to test for the thickness of smear layers against air or VPS impression materials: Position™ Penta™ Quick VPS Alginate Replacement (PPQ, 3M ESPE), Express™ 2 Penta™ Putty VPS Impression Material (E2P, 3M ESPE). Eight temporary crown and bridge materials were Protemp™ Plus Temporization Material (3M ESPE), Luxatemp® Automix (DMG), Luxatemp Fluorescence (DMG), Integrity™ Fluorescence (Dentsply), Kanitemp Royal (Kaniedenta), Structur Premium (VOCO), Structur 2 SC (VOCO), Acrytemp (Zhermack).

Each material was placed in Delrin-rings (d = 20 mm; h = 3.5mm) closed with glass plates on one side. The opposite side was either against air, Position Penta Quick or Express 2 Penta Putty. Specimens were removed after they were cured for 15 minutes at 23°C. Initial weighting (M1) was determined from the specimens after curing. Second weighting (M2) was determined after the specimens were cleaned with alcohol. In the case of impression materials, the impression plates were also weighted before and after materials were cured.

**Results:** Data was analyzed using One-way ANOVA with Fischer test, and a confidence interval of 95 %. Summary of results and mean values including standard deviations (in bracket) were calculated. Fischer test reveals that there were significant different between Protemp Plus material and all other groups against air and Express 2 Penta Putty. However, there was a significant between Protemp Plus material and all other groups against Position Penta Quick VPS Alginate Replacement, except to Luxatemp Fluorescence.

Material	Air [mg/cm]	PPQ [mg/cm]	E2P [mg/cm]
Protemp™ Plus	3.05 [0.08] <sup>a</sup>	1.35 [0.09] <sup>a</sup>	0.50 [0.16] <sup>a</sup>
Luxatemp® Automix	3.45 [0.18] <sup>a</sup>	2.06 [0.30] <sup>b,c</sup>	1.24 [0.18] <sup>b</sup>
Luxatemp® Fluorescence	3.62 [0.19] <sup>b,c</sup>	1.63 [0.17] <sup>a,b</sup>	1.01 [0.12] <sup>b</sup>
Integrity™ Fluorescence	3.87 [0.16] <sup>c</sup>	1.80 [0.12] <sup>b</sup>	1.15 [0.18] <sup>c</sup>
Kanitemp Royal	4.69 [0.26] <sup>d</sup>	2.40 [0.23] <sup>b,c</sup>	1.61 [0.17] <sup>c</sup>
Structur Premium	6.34 [2.10] <sup>a</sup>	3.42 [0.17] <sup>d</sup>	2.61 [0.35] <sup>d</sup>
Structur 2 SC	6.62 [3.90] <sup>a</sup>	3.67 [0.30] <sup>d</sup>	2.60 [0.23] <sup>d</sup>
Acrytemp	8.01 [0.17] <sup>i</sup>	5.54 [0.71] <sup>a</sup>	3.70 [0.43] <sup>a</sup>

Same letter indicates no significant difference within the same column.

**Conclusion:** Protemp™ Plus Temporization Material shows less smear layer compared to all other materials either against air or impression materials. The thicknesses of smear layers were lower against the impression materials than against air, which may be beneficial in the clinical situation.

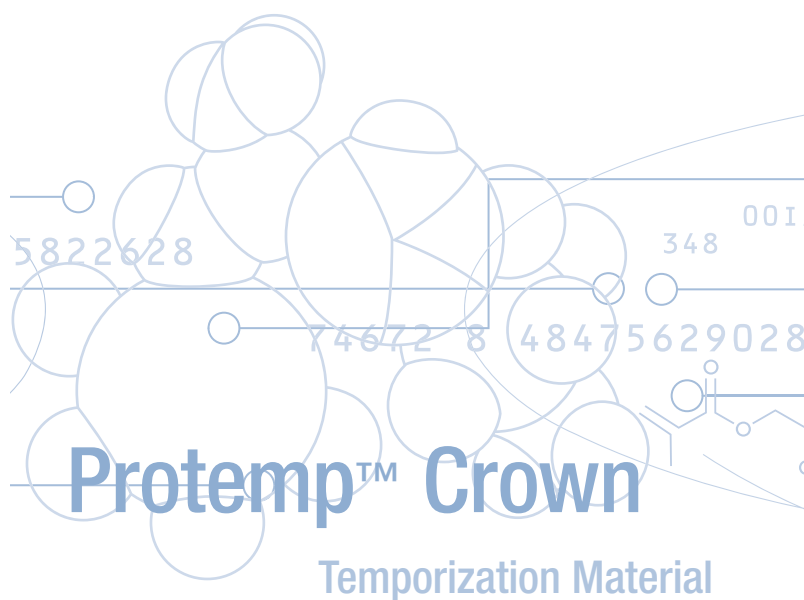
(sponsored in part by 3M ESPE)

### 3M ESPE Summary

**Aim of the study:** Comparison of the thickness of the inhibition layers of Protemp Plus temporization material versus other leading provisional crown and bridge materials.

**Results of the study:** The inhibition layers of all materials tested were lower against silicone impression materials than against air. Lowest inhibition layers were seen for Protemp Plus material.

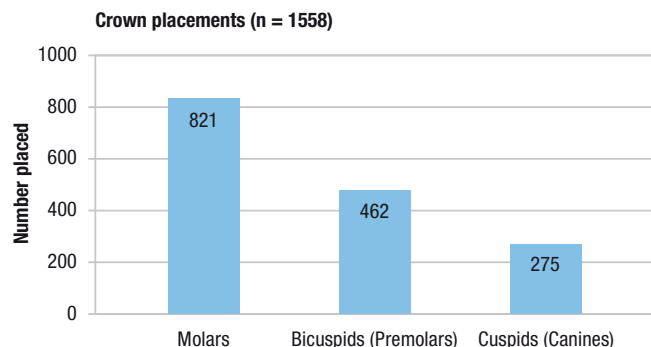




## Results from 3M ESPE field evaluation

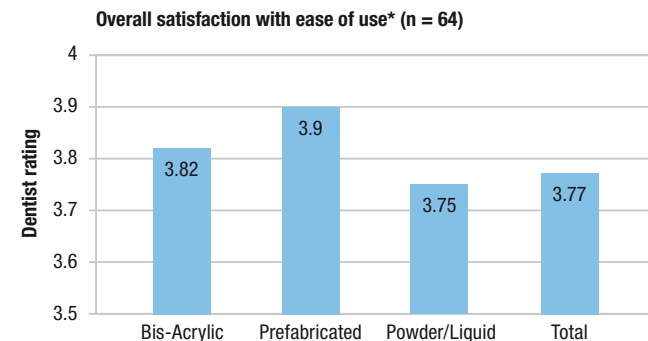
In a field evaluation conducted by 3M™ ESPE™, 105 dentist evaluators placed approximately 1,558 temporary single-unit crowns using Protemp™ Crown Temporization Material from 3M ESPE. The evaluators were selected to represent segments that preferentially use one of the following materials for their single-unit temporary restorations (Prefabricated Crown, Bis-Acrylic, Powder/Liquid). The evaluators completed a questionnaire to report their use and experiences with Protemp Crown material and effectiveness of the final restoration. Also, evaluators compared Protemp Crown material to the technique they use most often for single-unit temporary restorations.

**Placements:** Shown below is the total number of Protemp Crowns (temporary single-units) placed during the application test. The dentist evaluators used Protemp Crown material for the temporary restoration in the following teeth: molars accounted for 53 %, bicuspid (premolar) 30 % and cuspids (canine) 17 % of all placements.



## Ease of use

The overall satisfaction with ease of use was reported for Protemp™ Crown Temporization Material and recorded by the dentist evaluators based on the product used most often for single-unit temporization. The 64 US dentist evaluators rated the overall satisfaction and ease of use on a scale ranging from “very difficult” (1) to “very easy” (5). As shown in the graph, evaluators from the various temporization user groups rated the overall satisfaction with ease of use for Protemp Crown material high and therefore easy to use.



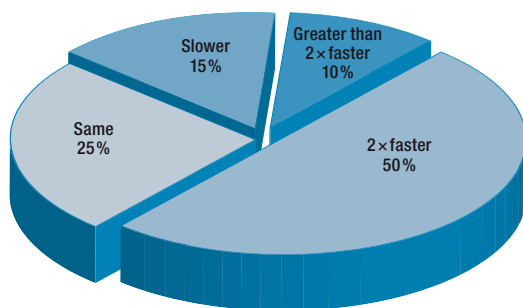
\*US data only/EU data not available

In addition, the evaluators were asked to rate the top 4 reasons why Protemp Crown material was easier to use. Dentists responded 1) no impression or matrix needed, 2) no mess or clean-up (i. e. hardware, mix tips), 3) easy to obtain occlusal fit, and 4) easy to obtain interproximal contacts.

## Fast

The speed of placement was rated at least twice as fast by 60 % of dentist evaluators when compared to the product used most often for single-unit temporary restorations.

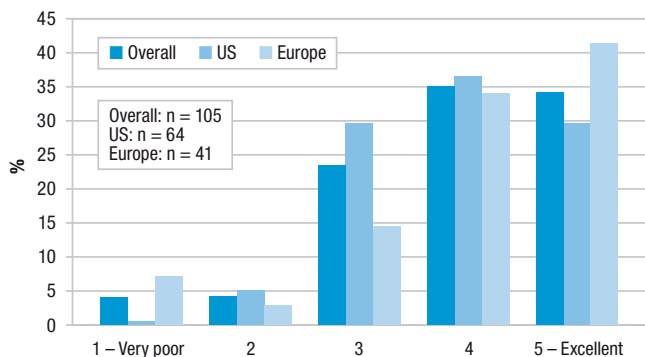
Speed of Placement (N = 105)



## Permanent crown fit

The fit of the permanent crown is one indication of the effectiveness of a temporary material and its ability to maintain space and to protect the preparation. During the application test, dentists rated – on a scale from “very poor” (1) to “excellent” (5) – the permanent crown fit after using Protemp™ Crown Material as the temporary restoration. The permanent crown fit following a Protemp Crown temporary was rated very good to excellent by the evaluators.

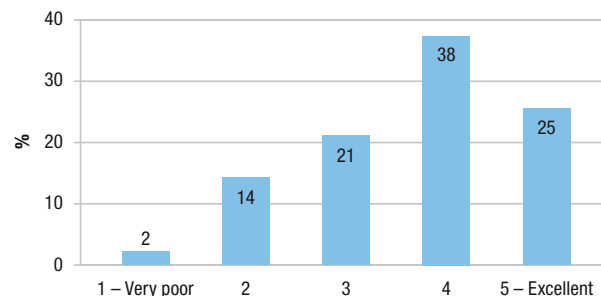
Permanent crown fit



## Esthetics

The esthetics of Protemp™ Crown Temporization Material was rated by the dentist evaluators on a scale from “very poor” (1) to “excellent” (5). Esthetics was rated good to excellent by 84 % of the dentist evaluators.

Esthetics



The results from this field evaluation indicate that Protemp Crown material has excellent clinical performance and proven acceptance when used for single-unit temporary applications in permanent dentition.

This innovative development allows Protemp Crown material to be considered the next generation temporary single-unit crown material. The clinical aspects and material properties ensure that the daily application in the dental operator is easy, fast, and provides for excellent strength and esthetics.

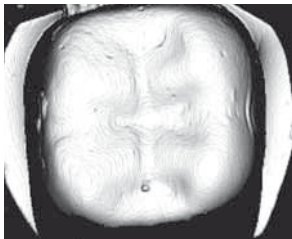


## Fracture resistance, wear and marginal adaptation of temporary composite crowns

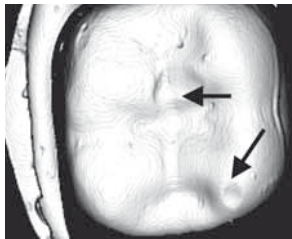
Published by: M. ROSENTRITT, R. LANG, and G. HANDEL, University of Regensburg, Germany  
IADR 2006, Brisbane, Australia, # 1561

**Objectives:** This *in vitro* study compared the fracture resistance, occlusal wear and marginal adaptation of experimental and conventional temporary composite molar crowns.

**Methods:** Single molar crowns were fabricated of an experimental composite material (3M ESPE) and two commercial provisional crown and bridge materials (Protemp™ 3 Garant™, 3M ESPE and Trim® II, Bosworth). The roots of the human molars were covered with an 1 mm thick polyether layer to imitate the periodontium and eight crowns of each group were luted with RelyX™ Temp NE Temporary Cement (3M ESPE). For simulating oral service, the crowns were thermal-cycled and mechanically loaded (TMCL: 1200 × 5°C/55°C, 480,000 × 50N, 1.66 Hz) with human antagonists and then axially loaded to failure in an universal testing machine (Zwick 1446; v=1mm/min). Failure detection was set to 10% of the maximum force. Occlusal wear was measured in comparison to the unworn surface by a 3D scanning device (Willitec). The marginal adaptation (criteria: perfect margin and marginal gap) was determined in a scanning electron microscope (Philips Quanta FEG 400) via replica-technique before and after TCML. Statistical analysis was performed with the Mann-Whitney-U-test (P=0.05).



Protemp™ Crown (before)



Protemp™ Crown wear (after)

SEM pictures: occlusal surface before/after mastication simulator test

### Results:

Fracture resistance	Experimental composite (3M ESPE)	Protemp™ 3 Garant™ (3M ESPE)	Trim® II (Bosworth)
Median [N]	1419	750	Failed during TCML
Q1/Q3	921/1516	507/1204	-/-

All Trim® II crowns failed due to fracture during thermal cycling and mechanical loading. Experimental composite crowns showed highest fracture resistance. For Protemp™ 3 Garant™ and experimental composite comparable marginal adaptation and wear was found.

**Conclusion:** Experimental composite and Protemp 3 Garant crowns showed fracture resistance, marginal adaptation and wear after artificial aging, which is expected to withstand the loading in posterior areas.

### 3M ESPE Summary

**Aim of the study:** To compare fracture resistance and wear of Protemp™ Crown Temporization Material and other temporary bis-acrylic materials before and after an *in vitro* 2-year chewing-simulation.

**Results of the study:** Protemp Crown material showed low wear, the highest fracture resistance and a high survival rate in this *in vitro* 2-year simulation and may therefore be considered for long-term temporization.

## A new temporary preformed curable crown material: mechanical properties

Published by: T. JONES, N. KARIM, E. WINTERS, D. JACOBS, and R. RUSIN,  
3M ESPE, St. Paul, MN, USA  
IADR 2007, New Orleans, LA, USA, # 0130

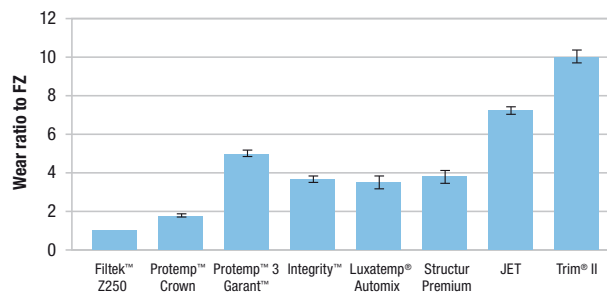
**Objectives:** The objective of this study was to compare the strength and 3-body wear characteristics of a novel preformed temporary composite crown material (Protemp™ Crown Temporization Material, 3M ESPE) with those of conventional crown temporization materials: Protemp™ 3 Garant™ (3M ESPE), Integrity™ (Dentsply), Luxatemp® Automix (DMG), Structur Premium (Voco), JET (Lang), and Trim® II (Bosworth). Filtek™ Z250 Restorative (3M ESPE) was used as a control.

**Methods:** For compressive (CS) and diametral tensile strength (DTS), samples were cured in 4 mm diameter glass tubes with the paste held under axial compression, then cut to 8 mm (CS) and 2 mm (DTS) in length. Samples of size 2 × 2 × 25 mm for flexural strength (FS) testing were cured in multipart PTFE molds. Specimens were conditioned in de-ionized water at 37° C for 24 hours prior to testing on an Instron machine. For wear testing, the ACTA 3-body wear device and methodology were used (Pallav et al., J. Pros. Dent. 59(4) 1988), wear data were normalized to the wear of Filtek Z250 Restorative (FZ). The data were analyzed via one-way ANOVA and compared with Tukey's T-test ( $p < 0.05$ ).

**Results:** Properties of the various materials are summarized in the following table.

**Conclusion:** Preformed Protemp Crown material exhibited comparable compressive and diametral tensile strength to conventional bis-acrylic materials. As well, Protemp Crown material showed the highest flexural strength and least wear of the temporary crown materials tested, and hence would be expected to perform well clinically.

	CS (MPa) Avg (SD) n = 6 – 10	DTS (MPa) Avg (SD) n = 6 – 10	FS (MPa) Avg (SD) n = 7 – 10	Wear ratio to FZ n = 3
Protemp™ Crown	320.3 (13.0)	78.9 (5.4)	139.8 (9.5)	1.72 (0.05)
Protemp™ 3 Garant™	305.6 (30.2)	48.0 (4.4)	76.4 (4.2)	5.04 (0.09)
Integrity™	287.7 (13.0)	56.5 (3.3)	70.6 (5.6)	3.63 (0.15)
Luxatemp® Automix	244.49 (21)	53.5 (4.7)	79.6 (2.6)	3.35 (0.33)
Structur Premium	376.7 (46.7)	72.5 (5.4)	74.9 (6.2)	3.82 (0.30)
JET	124.7 (19.2)	32.8 (3.8)	60.6 (1.4)	7.13 (0.22)
Trim® II	76.9 (7.7)	18.0 (2.5)	38.5 (2.7)	9.91 (0.27)



Comparison of wear of temporization materials versus Filtek™ Z250 Restorative (FZ).

### 3M ESPE Summary

**Aim of the study:** To compare the physical properties of preformed, malleable and light-curable Protemp™ Crown Temporization Material – indicated for short-term temporization – to standard short-term temporization materials.

**Results of the study:** Protemp Crown material performed similarly or better compared to standard temporization materials for compressive strength and diametral tensile strength. It demonstrated lowest wear and highest flexural strength.

Wear of provisional crown and fixed partial denture materials

Published by: C. J. KLEVERLAAN, A. WERNER, A. J. DE GEE, and A. J. FEILZER, ACTA, Universiteit van Amsterdam and Vrije Universiteit, Netherlands  
CED 2007, Dublin, Ireland, # 0350

**Objectives:** The aim of this study was to determine the three-body wear of five resin-based provisional materials: Protemp™ Crown Temporization Material (3M ESPE), Luxatemp® (DMG), Integrity™ (Dentsply), Structur Premium (Voco), and Trim® II (Bosworth).

**Methods:** Structur Premium, Integrity and Luxatemp were mixed by their automix systems and allowed to self-cure at room temperature. Trim II, a powder-liquid crown and bridge material, was mixed in the ratio P/L = 13/7 by volume, and after the rubbery state allowed to cure at RT in a pressure pan (at 2 Bar) for 5 minutes. Protemp Crown material was treated by special instructions from the manufacturer. Wear experiments were performed in the ACTA wear machine at various time periods after the start of curing.

**Results:** The table shows the consecutive wear in µm/200,000 cycles at five time moments. Statistically significant differences (two-way ANOVA) were found for the materials (P < 0.001) and the different time periods (P < 0.001). Comparing the mean wear within day one resulted in the following ranking: Protemp Crown < Integrity = Structur Premium < Luxatemp < Trim II. A decrease of the mean wear was observed for most materials during the first week.

**Conclusion:** The mean wear of Protemp Crown material was significantly lower at all time periods than the other investigated provisional materials. The observed mean wear of Protemp Crown material is in the order of permanent composite restorative materials, such as Tetric® Ceram with a mean wear of 76(2) µm at day one.

Wear in µm/200,000 cycles determined in the ACTA wear machine at 15 N antagonist load.

Age	Protemp™ Crown	Luxatemp®	Integrity™	Structur Premium	Trim® II
1 day	84 (7)	135 (3)	129 (7)	128 (5)	237 (6)
4 days	76 (3)	116 (2)	112 (5)	105 (2)	232 (5)
1 week	68 (3)	113 (2)	110 (3)	92 (1)	204 (13)
4 weeks	67 (5)	111 (6)	111 (6)	90 (4)	198 (6)
8 weeks	6 (3)	108 (6)	103 (4)	97 (4)	158 (10)

Materials were supplied by 3M ESPE AG Seefeld, Germany.

Mechanical properties

3M ESPE Summary

**Aim of the study:** Assess *in vitro* three-body wear for Protemp™ Crown Temporization Material, a new preformed single-unit composite restoration, in comparison to four other temporary crown and bridge materials.

**Results of the study:** Protemp Crown material showed the significantly lowest wear rates compared to the other crown and bridge materials tested. Values were similar to composite materials used for permanent restorations.

## Handling properties of novel preformed, malleable, and curable temporary crowns

Published by: N. KARIM, D. JACOBS, and T. JONES, 3M ESPE, St. Paul, MN, USA  
IADR 2007, New Orleans, LA, USA, # 0129

**Objectives:** A novel preformed, malleable and light-curable composite crown, Protemp™ Crown Temporization Material (3M ESPE), has been developed to simplify the procedure for short-term temporization. The objective of this investigation is to characterize the rheological properties of the malleable Protemp Crown material.

**Methods:** A Rheometric Scientific Inc. ARES rheometer and a Texture Technologies Corp. TA-XT2i Texture Analyzer were used to measure rheological properties of the uncured Protemp Crown material in comparison with a universal composite filling material, Filtek™ Z250 (3M ESPE), a packable composite filling material, Filtek™ P60 (3M ESPE) and a dental model wax, Modern #3 Pink (Heraeus Kulzer). Standard composites (Filtek P60, Filtek Z250) were equilibrated (25° C) for at least 15 minutes prior to testing. Waxlike materials (Modern #3 Pink, Protemp Crown material) were equilibrated for at least 96 h prior to testing. The data were analyzed via one-way ANOVA and compared with Tukey's T-test ( $p < 0.05$ ).

**Results:** Results of the experiments are summarized in the following table.

**Conclusion:** At room temperature, uncured Protemp Crown material has an equivalent viscosity to a dental wax, and is statistically more viscous than either a packable (Filtek P60) or universal (Filtek Z250) composite. At 37° C, Protemp Crown materials is statistically more viscous than Modern #3 Pink, Filtek P60 or Filtek Z250. By texture analyzer, Protemp Crown material is statistically softer than Modern #3 Pink, but statistically harder than either Filtek Z250 or Filtek P60. Uncured Protemp Crown material has the right balance of rheological properties for the novel application of a preformed crown. It is free-standing and maintains its shape in storage and handling, but can be easily reshaped and customized at body temperature by a dental professional for excellent adaptation on a tooth prep.

Material	Texture Analyzer – Hardness (g, n = 3–4)		ARES Rheometer – Complex Viscosity (Pa·s, n = 3–4)	
	25° C	37° C	25° C	37° C
	avg (sd)	avg (sd)	avg (sd)	avg (sd)
Protemp™ Crown	1025 (44)	391 (16)	$1.15 \times 10^7$ ( $1.8 \times 10^6$ )	$5.64 \times 10^6$ ( $5.9 \times 10^5$ )
Modern #3 Pink	3744 (103)	1765 (149)	$1.49 \times 10^7$ ( $3.1 \times 10^6$ )	$2.28 \times 10^6$ ( $3.0 \times 10^5$ )
Filtek™ Z250	242 (24)	94 (6)	$2.75 \times 10^3$ ( $1.5 \times 10^3$ )	$4.05 \times 10^3$ ( $2.4 \times 10^3$ )
Filtek™ P60	414 (48)	164 (20)	$1.09 \times 10^4$ ( $1.5 \times 10^3$ )	$1.32 \times 10^4$ ( $6.5 \times 10^3$ )

### 3M ESPE Summary

**Aim of the study:** To characterize the rheology of a new material developed for a novel preformed, malleable and light curable composite crown indicated for short-term temporization.

**Results of the study:** At room temperature uncured Protemp™ Crown Temporization Material has a wax-like consistency which maintains its shape and is easily malleable. At body temperature the uncured material viscosity allows for easy reshaping and customization in order to obtain a good fit of the restoration.

## A comparative study between two preformed provisional crown fabrication techniques

Published by: V. TSAKALELLI, N. CHAIMATTAYOMPOL, E. ANTONELLOU, and D. PARK, Tufts University School of Dental Medicine, Boston, MA, USA  
IADR 2008, Toronto, ON, Canada, # 3101

Recently, there is a newly introduced preformed single provisional restoration Protemp™ Crown Temporization Material (3M ESPE) proposed as an innovative, revolutionary breakthrough temporization material and technique. There is no original research of the comparison between Protemp Crown material to polycarbonated temporary crowns (3M ESPE).

**Objectives:** This current *in vitro* study was conducted to compare the amount of time spent to fabricate the different restorations and evaluate the quality of marginal integrity, interproximal and occlusal contacts of Protemp Crown material and polycarbonated temporary crowns.

**Methods:** Tooth #4 secured in Columbia typodont was prepared in mannequin with chamfer finish line. Forty (N = 40) single provisional crowns were fabricated on the prepared abutment tooth using two different techniques, Group 1 – prefabricated polycarbonated crowns and Group 2 – preformed Protemp Crowns, (20/Gp). The amount of time spent for fabrication (including relining, when necessary) was recorded. Two calibrated and trained prosthodontists evaluated the marginal integrity and the interproximal contacts based on the Modified United States Public Health (USPHS) criteria. Occlusion was also evaluated. The amount of time spent to fabricate provisional crowns of both groups was recorded and statistically analyzed (ANOVA,  $p < 0.05$ ) and the rating of marginal integrity, interproximal contact and occlusion were recorded and statistically analyzed (Mann-Whitney U test,  $p < 0.01$ ).

**Results:** The results revealed that the amount of time spent to fabricate provisional crowns is statistically significant different between Group 1 and Group 2. The mean time to fabricate a provisional crown in Group 2 is less than in Group 1. Mann-Whitney U test was used to analyze marginal integrity, interproximal contact and occlusion. There were no statistically significant differences between the two techniques.

**Conclusion:** The use of Protemp™ Crown Temporization Material significantly reduced the time spent to fabricate a provisional crown. Protemp Crown technique was equivalent to polycarbonated provisional crown technique.

### 3M ESPE Summary

**Aim of the study:** To compare time needed for placement and clinical outcome of Protemp Crown material and established polycarbonate crowns.

**Results of the study:** While the placement procedure was significantly faster with Protemp Crown material, the clinical outcome for marginal integrity, interproximal contact and occlusion was comparable for both products.

## Temporary crown clinical performance in a practice-based Research network (PROH)

Published by: T. J. HILTON<sup>1</sup>, J. L. FERRACANE<sup>1</sup>, C. BARNES<sup>1</sup>, and R. C. RANDALL<sup>2</sup>,  
<sup>1</sup>Oregon Health & Science University, Portland, USA, <sup>2</sup>3M ESPE Dental Products, St. Paul, MN, USA  
IADR 2008, Toronto, ON, Canada, # 2348

**Objectives:** The purpose of this study was to evaluate the performance of Protemp™ Crown Temporization Material, in 101 crown prepared teeth in the permanent dentition of adult patients.

**Methods:** Ten members of the PROH practice-based research network each placed 10 temporary Protemp Crowns while fabricating crowns on 101 permanent posterior teeth using standardized preparation/luting criteria. Baseline (tooth preparation appointment) and recall (permanent crown cementation appointment 2–4 weeks later) assessments were completed for each temporary crown using modified Ryge criteria. Additionally, practitioners rated wear, bruxism, temperature and biting sensitivity (VAS). Changes from baseline to the recall appointment were analysed using McNemar's test for binary outcomes and the paired t-test for quantitative outcomes. Associations between measures were assessed using logistic regression and generalized estimating equations. A 0.05 level of statistical significance was used for all analyses.

**Results:** The overall retention rate of the temporary crowns was 87 %, and the overall fracture rate was 11 %. Patients identified as bruxers exhibited significantly greater wear than non-bruxers. There were significant changes between baseline and recall measures in temperature and biting sensitivity (VAS) and gingival index, but the changes into a better level were statistically balanced by changes to a worse level.

There were no significant differences in occurrence of baseline/recall temperature sensitivity or biting sensitivity, nor was there a significant change in anatomic form from baseline to recall. Practitioners noted that a few temporary crowns demonstrated a marked color change.

**Conclusion:** In general, Protemp™ Crown Temporization Material performed satisfactorily as an interim restoration.

(Supported by 3M ESPE)

### 3M ESPE Summary

**Aim of the study:** Determine clinical performance of Protemp Crown temporization material, a new preformed temporary composite restoration for single units.

**Results of the study:** Satisfactory overall clinical performance at recall 2–4 weeks after replacement with a retention rate of 87 % and fracture rate of 11 %.



## Clinical study on marginal fidelity of temporary crown systems

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Published by: J. A. SORENSEN, R. TROTMAN and P. N. SORENSEN,  
Pacific Dental Institute, Portland, OR, USA  
IADR 2008, Toronto, ON, Canada, # 1567

**Objectives:** A new temporary crown system made of a preformed self-supporting malleable composite (Protemp™ Crown Temporization Material, 3M ESPE) facilitates rapid fabrication of temporary crowns. This study compared the clinical marginal fit of Protemp Crown material to molded temporary crowns made with autopolymerized BisAcryl (Luxatemp®, DMG).

**Material and methods:** Patients having posterior crowns made were randomly assigned to a temporary crown group: Protemp Crown material. The appropriate size tooth form was selected, unwrapped, trimmed with scissors, pressed over the tooth preparation, and molded to margins with fingers and instruments while patient was biting. It was initially light-cured (LC), gently teased off of tooth and LC for 20 sec.\* Luxatemp material was placed in a vinyl polysiloxane (VPS) mold with an auto-mixing gun, seated on tooth and allowed to polymerize. The mold was removed and crown retrieved. Crowns were trimmed with temporary polishing system (Brasseler) and cemented with either System®link (Ivoclar Vivadent) or DYCAL® (Caulk Dentsply). At crown delivery appointment a small impression was made of temporary crown with low and high viscosity VPS. Epoxy resin (Buehler) was poured in impressions. Epoxy crown replicas were sectioned faciolingually into halves for premolars yielding four measurements and thirds for molars yielding eight measurements. Crowns evaluated: 13-Luxatemp, 17-Protemp Crown material. Measurement of marginal crepancies was according to methodology described by Sorensen (J Prosthet Dent 1990;64:18). Vertical discrepancy = marginal gap size; horizontal discrepancy: + = overcontoured, - = undercontoured.

\*on each surface (buccal, lingual, occlusal), 60 sec. in total (manufacturer comment)

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**Results:** Mean(sd) Marginal Discrepancy [µm]:  
Vertical: Protemp™ Crown Temporization Material = 665(363),  
Luxatemp® = 819(513),  
Horizontal: Protemp Crown material = +352(434),  
Luxatemp = +193(691).

ANOVA, Tukey's test showed significant difference between Protemp Crown temporization material and Luxatemp for vertical and horizontal discrepancies at  $p < 0.05$ .

**Conclusion:** Significant differences existed for mean vertical and horizontal marginal discrepancies between temporary crown systems. Both systems had marginal overcontouring.

### 3M ESPE Summary

**Aim of the study:** Clinical assessment of marginal fit of Protemp Crown temporization material, a preformed composite crown vs. Luxatemp, an established autopolymerizing bisacryl applied in to the matrix.

**Results of the study:** Protemp Crown material showed a significantly reduced marginal gap. Both crown types were overcontoured.



Notes:

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