

about 72.5% by weight (55.6% by volume) for the translucent shades and 78.5% by weight (63.3% by volume) for all other shades.

SDR Flow (Dentsply USA)

SDR Flow is a posterior Bulk fill flowable base that is one-component, fluoride-containing, visible light-cured radio-opaque resin composite restorative material. It is designed to be used as a base in Class I and II restorations. It is also suitable as a stand-alone restorative material in non-occlusal-contact applications. SDR material has handling characteristics typical of a ‘flowable’ composite, but can be placed in 4 mm increments with minimal polymerization stress. It is available in one universal shade. When used as a base/liner, it is designed to be overlaid with a methacrylate based universal/posterior composite for replacing missing occlusal or facial enamel (Figure 6).



Figure 6: SDR Flow (Dentsply, USA, 2011)

Composition of the material according to the manufacturers was as follows:

- Resin matrix: SDR patented urethane dimethacrylate resin, dimethacrylate resin and di-functional diluent resin.
- Inorganic fillers (68% by weight and 45% by volume): barium and strontium alumino-fluoro-silicate glasses.
- Photoinitiating system.
- Colourant.

3.2. Flexural Strength Test

3.2.1. Preparation of test specimens

Moulds were made using laboratory putty and cold cured acrylic resin, for the preparation of test specimens 25 ± 2 mm x 2.0 ± 0.1 mm x 2.0 ± 0.1 mm (Figure 7), according to ISO 4049:2009 for flexural strength testing (Figure 7).

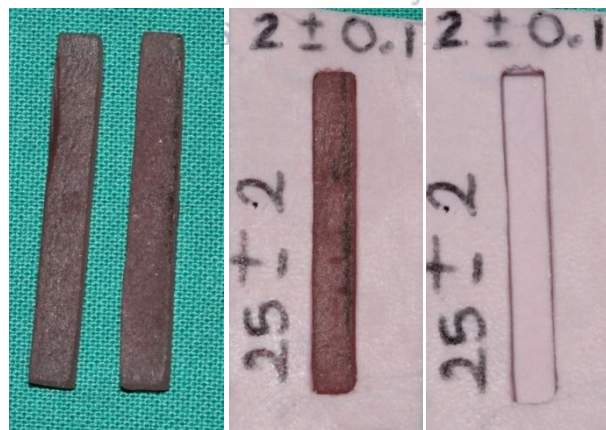


Figure 7: Mould for flexural strength test specimens (ISO 4049:2009)

48 Specimens were prepared and divided randomly into 4 groups with 12 specimens per material. The materials were prepared in accordance with the manufacturer's instructions and immediately placed as evenly as possible without bubbles or voids in the moulds with a slight

excess. A transparent film was placed on the material in the mould and this was covered with a glass slab. Pressure was applied to displace the excess material (Figures 8 & 9). The specimens were then cured according to the manufacturer's instructions (Figure 9). Specimens were light cured for 20 seconds using a DeepCure LED curing light (3M ESPE, USA). The light was checked for light output using a Cure Rite light meter (Dentsply, USA). The light output was recorded at 1000 mWatts/cm. The curing light was checked after every 12 samples. All specimens were placed in distilled water maintained at 37 ± 1 °C for 24 hours before testing.

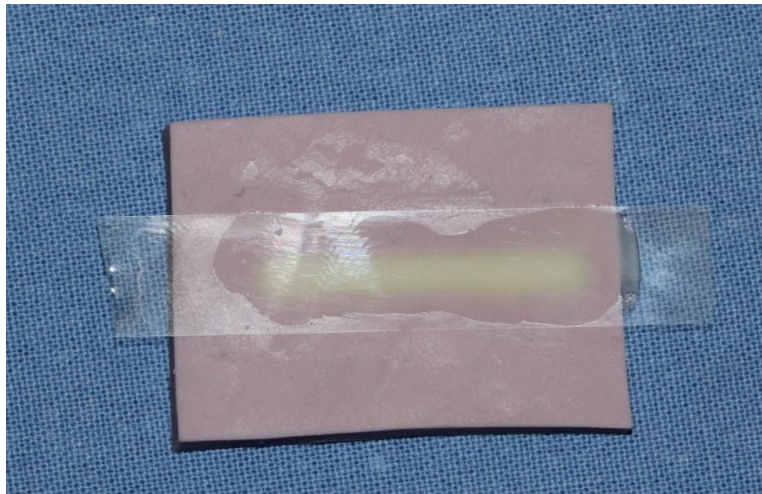


Figure 8: Transparent film to remove excess material.

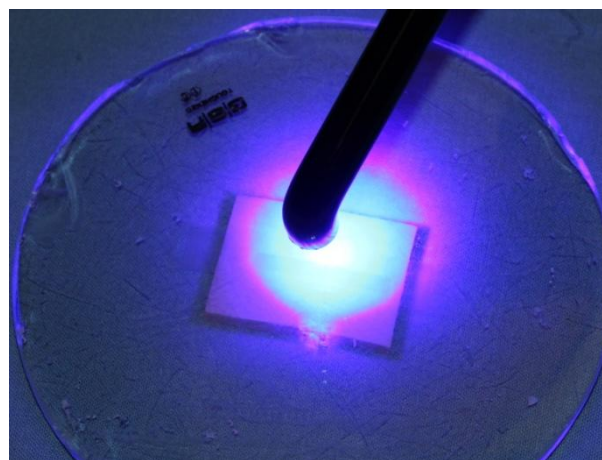


Figure 9: Glass slab added to apply pressure and curing of material.

3.2.2 Testing specimens (Flexural strength)

The specimens (Figure 10) were tested using a Tinius Olsen H10KT Universal testing machine (Horsham, USA) (Figure 11). Each specimen was placed and secured in a jig (Figure 12). The angle of load for the specimens was at 90° to the long axis. The point of contact was at the centre of the specimen length. Load was applied at a crosshead speed of 1 mm/min on the core material until failure occurs. The force that was applied at time of failure or fracture was recorded in Newton (N) (Figure. 12).

Flexural strength was then calculated using the following equation and recorded in megapascals (MPa): ISO 4049:2009

$$\sigma = 3PL/2wt^2$$

Where P is the maximum load exerted on the specimen; L is the distance (mm) between the supports ± 0.01 mm; w is the width (mm) of specimen immediately prior to testing; and t is the thickness (mm) of specimen measured immediately prior to testing. The experimental variables of specimen size, shape, testing configuration, fabrication procedure, temperature, humidity, storage time, storage temperature, strain rate, and set time were all standardized in this study. All specimens were treated identically throughout this study, which was based on American Dental Association (ADA) Specification No. 27.

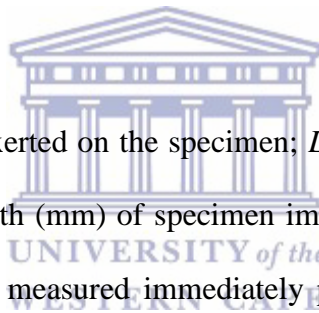




Figure 10: Cured specimen.

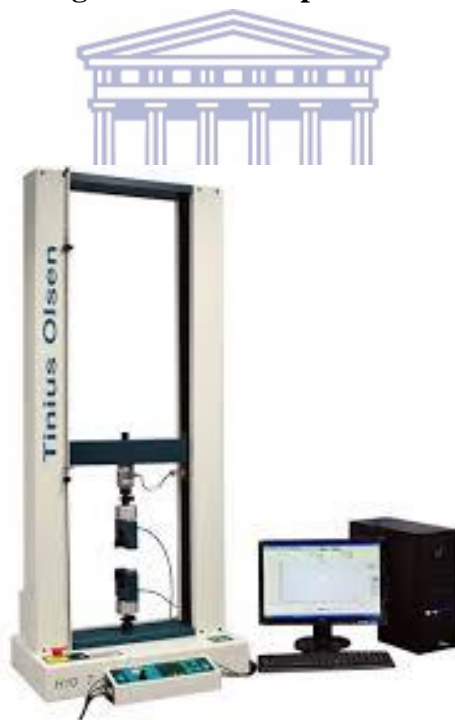


Figure 11: Tinius Olsen H10KT Universal Testing machine (Horsham, USA)

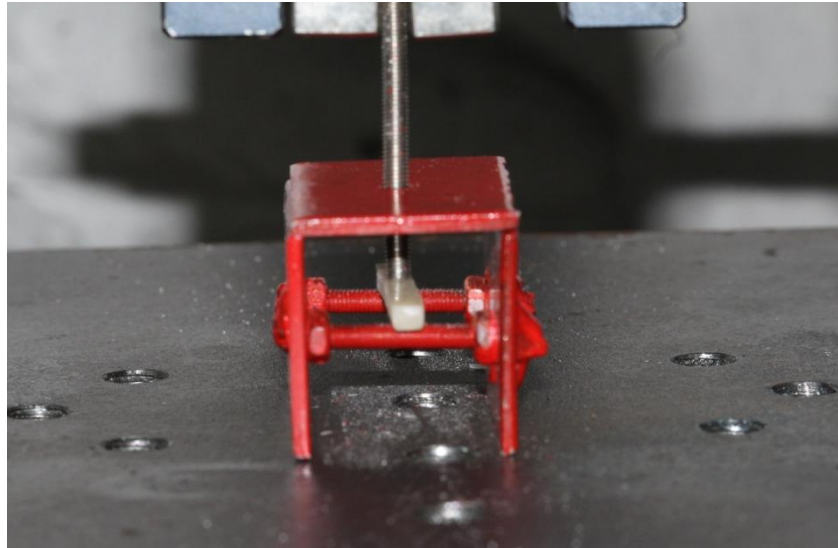


Figure 12: Testing Flexural strength.

3.3. Shear Bond Strength Testing

3.3.1. Cavity Preparation and placement of the core material.

120 teeth were used for this part of the study. The teeth were randomly divided into 4 groups of 30 teeth each ($n=30$); based on the restorative materials being tested. A cavity preparation (Figure 13) was made in the dentine with a tungsten carbide fissure bur (SS White, Lakewood, USA) and water-sprayed high speed hand piece (NSK, Japan). The tooth was sectioned half the width and length of the anatomic crown of the teeth. The size of the section was 7 ± 0.5 mm, inciso-cervically and 3.5 ± 0.3 mm in a labio-palatal direction. The teeth were sectioned parallel to the incisal edges, 1 mm above the cemento-enamel junction. The protocol was adopted from a study by Combe et al (1999); which evaluated the mechanical properties of direct core materials (Figure 14).



Figure 13: Cavity Preparation for central incisor teeth.

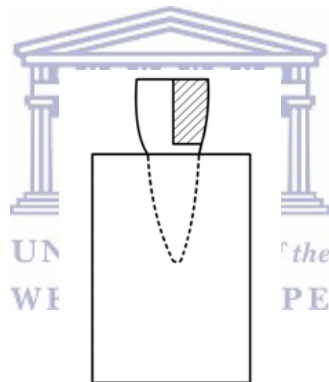


Figure 14: Diagram of tooth preparation and restoration (Combe et al., 1999).

Vitremer was placed in all cavities with pulpal exposure prior to core build up. The burs were changed after every 5 cavity preparations. The dentine surfaces were polished using a medium grit (light blue), Sof-Lex disc (3M ESPE, Dental Products, Germany) and mandrel. Each tooth root was aligned with the help of a surveyor (Dentalfarm, Torino, Italy) and mounted with acrylic resin into a PVC tube with a diameter of 20 mm, 2 mm below the cemento-enamel junction (Figures 15 & 16).



Figure 15: Surveyor used to align the teeth parallel (Dentalfarm, Torino, Italy)

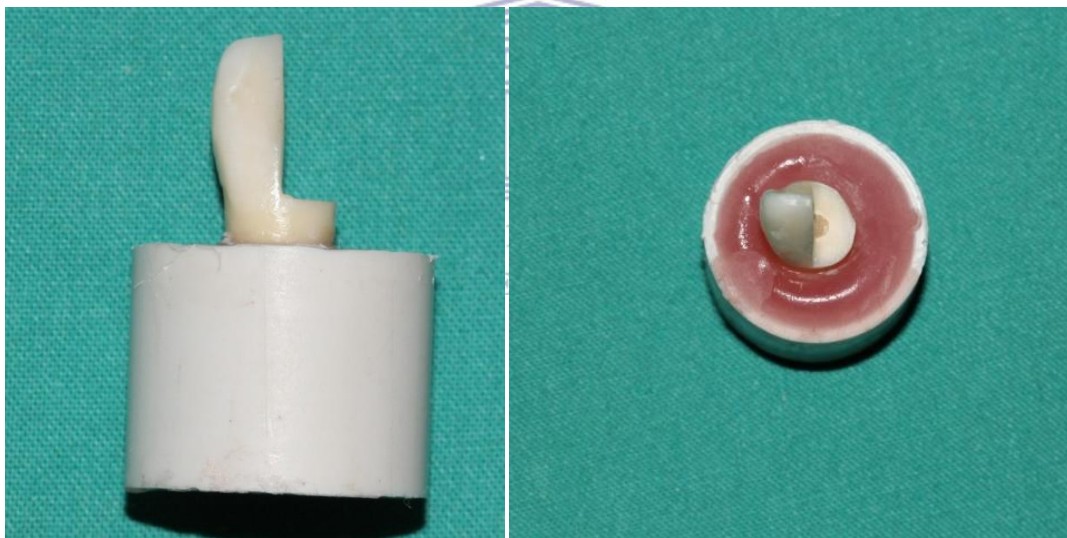


Figure 16: Parallel alignment of teeth in acrylic resin and PVC tubes.

All teeth and materials were randomly divided into 4 groups and materials were manipulated according to manufacturer's instructions to build up the core. Subsequently, the specimens were stored in distilled water at 37 °C for 24 hours prior to testing (Figure 17).



Figure 17: Teeth restored according to manufacturer instructions and randomly divided.

3.3.2. Testing of the core materials (Shear Bond strength)

This experiment was performed using a Tinius Olsen H10KT Universal testing machine (Horsham, USA) (Figure 11).

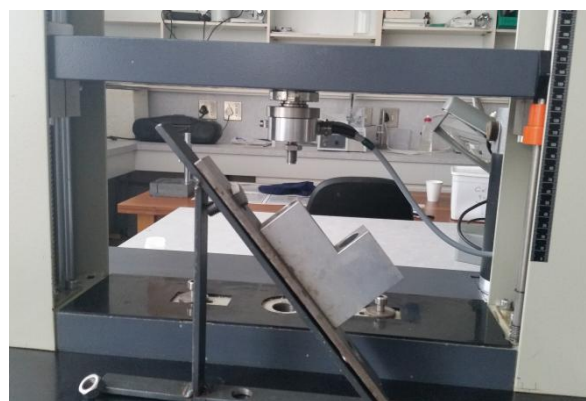
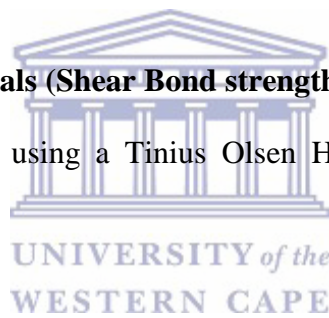


Figure 18: Specimen supported on a Jig.

Each specimen was placed and secured in an adapted jig (Figure 18). The angle of load for the incisor teeth was at 90° to the long axis of the tooth. The point of load was 2 mm apical to the incisal edge (Figure 19). This angle represented the axis formed by the maxillary and mandibular teeth in a class I dentoalveolar relationship (Figure 20).

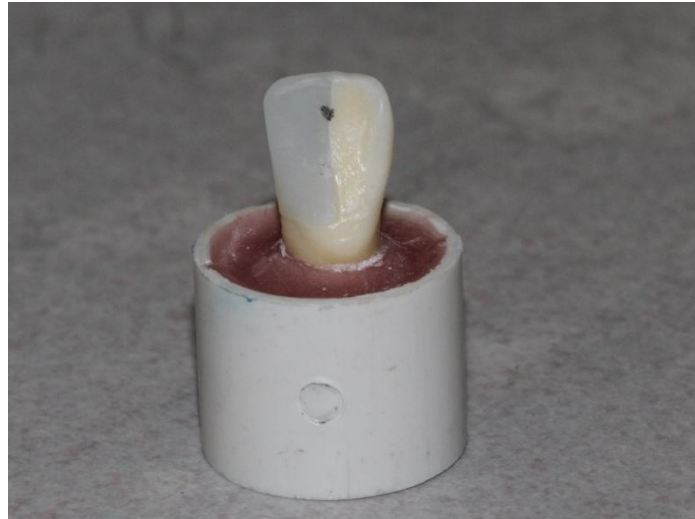


Figure 19: Point of load application.

UNIVERSITY of the
RN CAPE

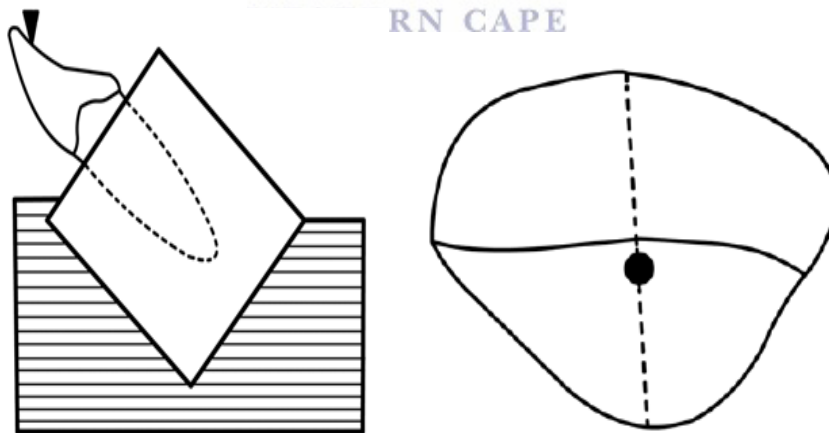


Figure 20: Angle of load of the maxillary and mandibular incisor teeth (Markovic, et al., 2011)

Load was applied at a crosshead speed of 0.5mm/min on the palatal surface, at the adhesive interface formed between the dentin and test material. The load was applied half on the tooth and half on the core material until failure occurs. The force that was applied at time of failure or fracture was recorded in megapascals (MPa).

3.4 Evaluation of failure patterns

10 randomly selected specimens from all 4 groups were examined using a Light Microscope (Wild Heerbrugg M5, Switzerland) to study the failure patterns of the materials tested (Figure 21 & 22). 2 operators were used to independently assess the failure patterns. Operators were calibrated before assessing the samples under light microscope of 20x's magnification. If there are discrepancies between the operators with the samples a consensus was reached and documented.



Figure 21: Light microscope: Wild Heerbrugg M5 (Switzerland)

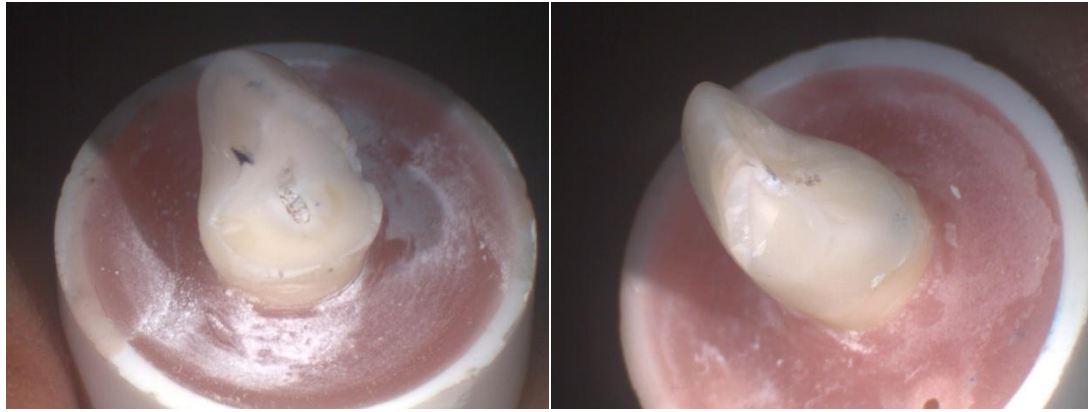
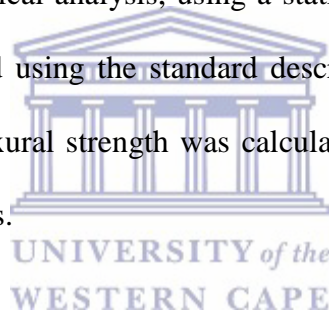


Figure 22: Failure modes under light microscope

3.5. Statistical Analysis

The data was captured for statistical analysis, using a statistical program (SPSS version 21, IBM, USA). Data was evaluated using the standard descriptive and comparative statistics. The shear bond strength and flexural strength was calculated at the ratio of maximum load recorded at failure in megapascals.



CHAPTER 4

Results

4.1 Data analysis

The results were recorded on a Microsoft Excel 2010 spreadsheet (Microsoft Corporation, USA) and the data was analysed using SPSS Statistical Software Ver21 (IBM, USA). A non-parametric analysis was performed at significance level of $p < 0.05$ to compare the shear bond strength and flexural strength of the various materials. The results are presented in tables and graphs (Box and Whisker plots).

4.2. Results

4.2.1. Flexural strength

48 Specimens which were divided into 12 specimens per material were tested to determine the flexural strength of the 4 core build-up materials. The number of observations of strength measurement of four different materials is presented in Table 6.

Table 6: Flexural Strength measurement the materials.

		Material		
		Frequency	Percent	Cumulative Percent
Valid	Filtek	12	25.0	25.0
	Surefill	12	25.0	50.0
	CoreXflow	12	25.0	75.0
	Paracore	12	25.0	100.0
	Total	48	100.0	

The mean flexural strength (FS) was highest for CoreXflow followed by ParaCore. The Mean FS values for CoreXflow, ParaCore, SDR Surefill and Filtek Supreme XTE obtained were 383.5 Mpa, 356.5 Mpa, 324.1 Mpa and 311.7 Mpa respectively (Table 7).

Table 7: Descriptives of Filtek, Surefill, CoreXflow and ParaCore

Mpa						
Material	Mean	N	Std. Deviation	Median	Minimum	Maximum
Filtek	311.7417	12	42.82345	297.6500	261.00	390.40
Surefill	324.1091	12	24.32893	314.0000	293.90	365.60
CoreXflow	383.5750	12	33.99778	384.3500	331.40	443.90
Paracore	356.5909	12	14.33642	357.6000	332.80	381.00
Total	344.1630	48	41.69655	350.0500	261.00	443.90

A significant difference in FS was observed between the materials (One-way ANOVA and Dunn-Sidak ($p < 0.05$)) (Figures 23 & 24). No significant difference was found between the 2 composite restorative materials, Filtek and SDR SureFill ($p > 0.05$) and between the 2 core build-up materials, CoreXflow and ParaCore ($p > 0.05$). A significant difference was found between Filtek & SDR and CoreXflow & ParaCore ($p < 0.05$).

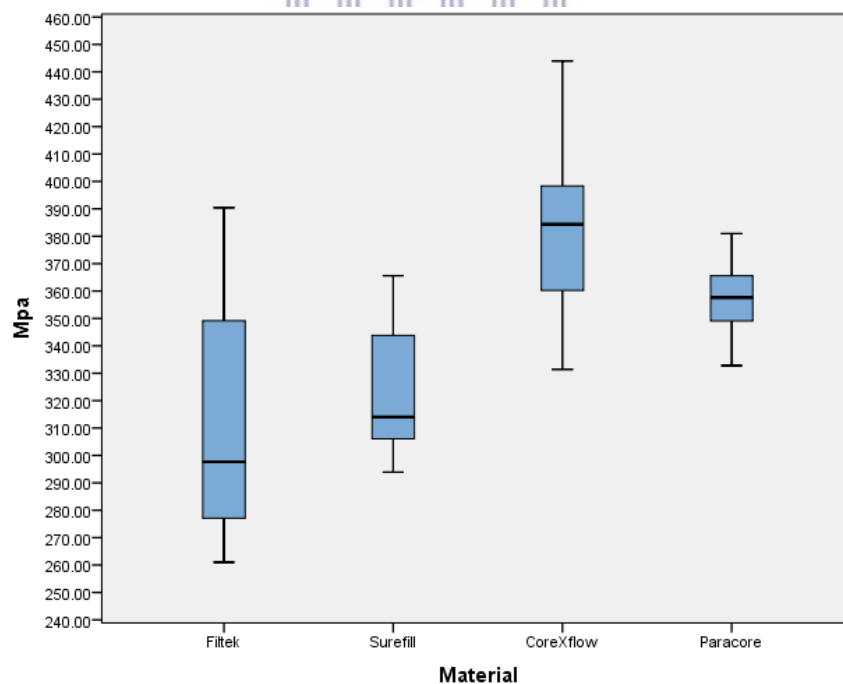


Figure 23: Boxplot: Comparison of flexural strength.

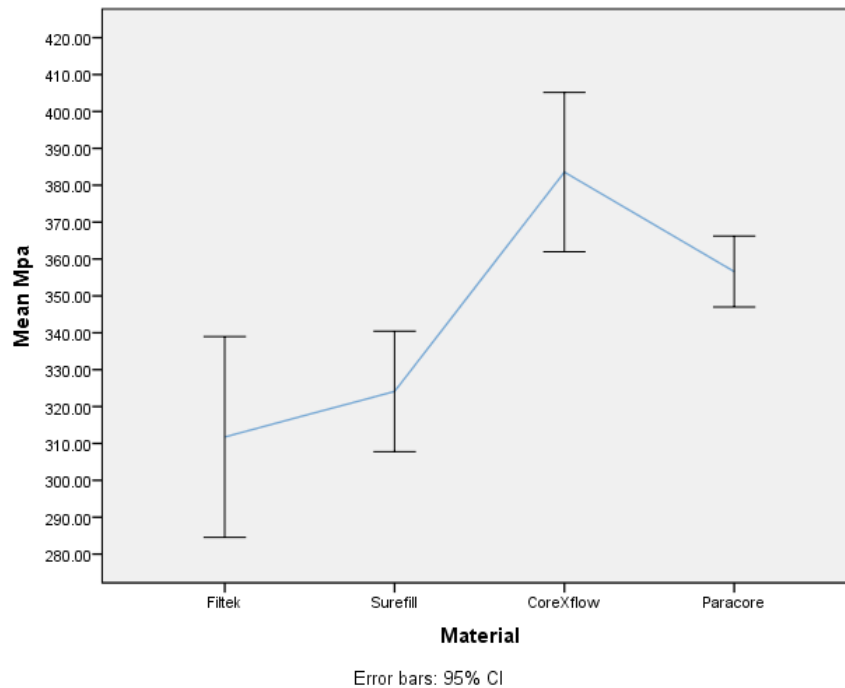


Figure 24: Means of flexural strength with 95% CI per material.

A nonparametric One Way Anova (Kruskal-Wallis) was used to analyse the differences between the materials (Table 8).

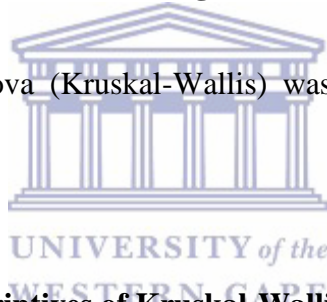


Table 8: Descriptives of Kruskal-Wallis per material.

Ranks			
	Material	N	Mean Rank
Mpa	Paracore	12	27.82
	CoreXflow	12	36.00
	Filtek	12	13.83
	Surefill	12	16.09
	Total	48	

The mean rank was the highest for CoreXflow followed by ParaCore. The Mean rank for CoreXflow, ParaCore, SDR and Filtek obtained were 36 Mpa, 27.8 Mpa, 16 Mpa and 13.8 Mpa respectively (Table 8).

Table 9: Pairwise comparisons (Dunn-Sidak)

Pairwise Comparisons of Material		
Sample 1-Sample 2	Std. Error	Sig.
Filtek-Surefill	5.602	.687
Filtek-Paracore	5.602	.013
Filtek-CoreXflow	5.479	.000
Surefill-Paracore	5.723	.040
Surefill-CoreXflow	5.602	.000
Paracore-CoreXflow	5.602	.144

Multiple comparisons were performed using the Pairwise comparisons test (Dunn-Sadak) to determine if there were any significant differences in flexural strength of the materials tested (Table 9). When flexural strength was analysed there was a significant difference between the materials specifically designed as core build-up materials (CoreXflow and ParaCore) and the conventional composite materials being advocated as core build-up materials (Filtek Supreme XTE and SDR Surefill) ($p < 0.05$, Dunn-Sadak). No significant difference in flexural strength was found between the conventional composites ($p > 0.05$). No significant difference was also found between the core materials (CoreXflow and ParaCore) ($p > 0.05$). A significant difference was found between Filtek and Paracore and Filtek and CoreXflow ($p < 0.05$). A significant difference was also found between SDR and Paracore and SDR and CoreXflow ($p < 0.05$).

4.2.2. Shear Bond Strength

The mean Shear Bond Strength (SBS) was highest for SDR followed by ParaCore. The Mean SBS values for SDR, ParaCore, Filtek Supreme XTE and CoreXflow, obtained were 147.6 N, 142 N, 137 N, 119.2 N respectively (Table 10).

Table 10: Mean SBS per material

Material	Dependent Variable: SBS					
	N	Mean	Std. Dev	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
ParaCore	10	142.000	36.08	8.691	124.318	159.682
CoreXFlow	9	119.250	16.99	9.717	99.481	139.019
Filtek	10	137.200	27.00	8.691	119.518	154.882
Surefill	9	147.667	24.04	9.161	129.029	166.305

No statistical significance difference in shear bond strength were observed between the materials tested (One-way ANOVA and post hoc Tukey's test ($p < 0.05$)) (Figures 25 & 26).

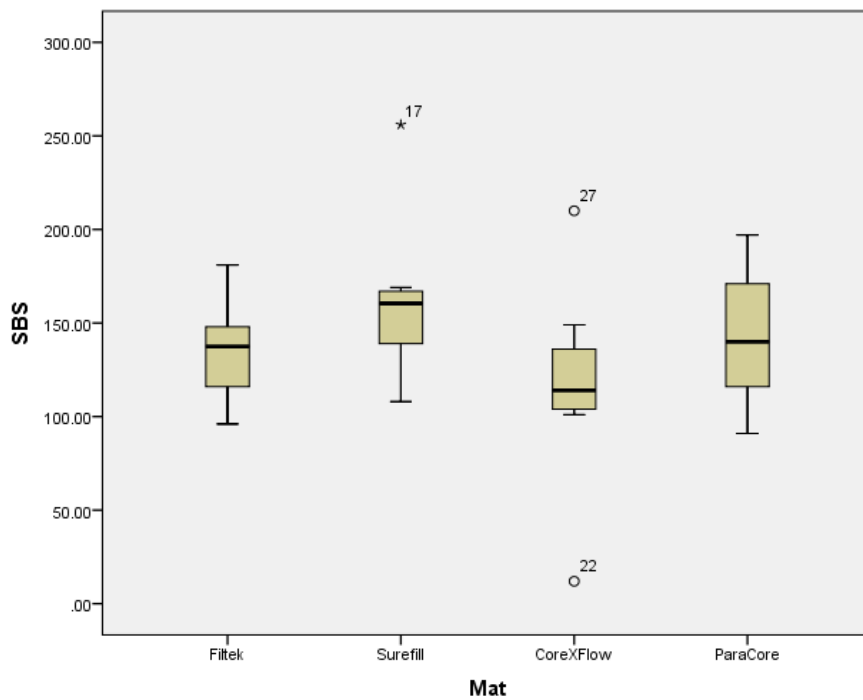


Figure 25: Boxplot: Comparison of Shear Bond Strength.

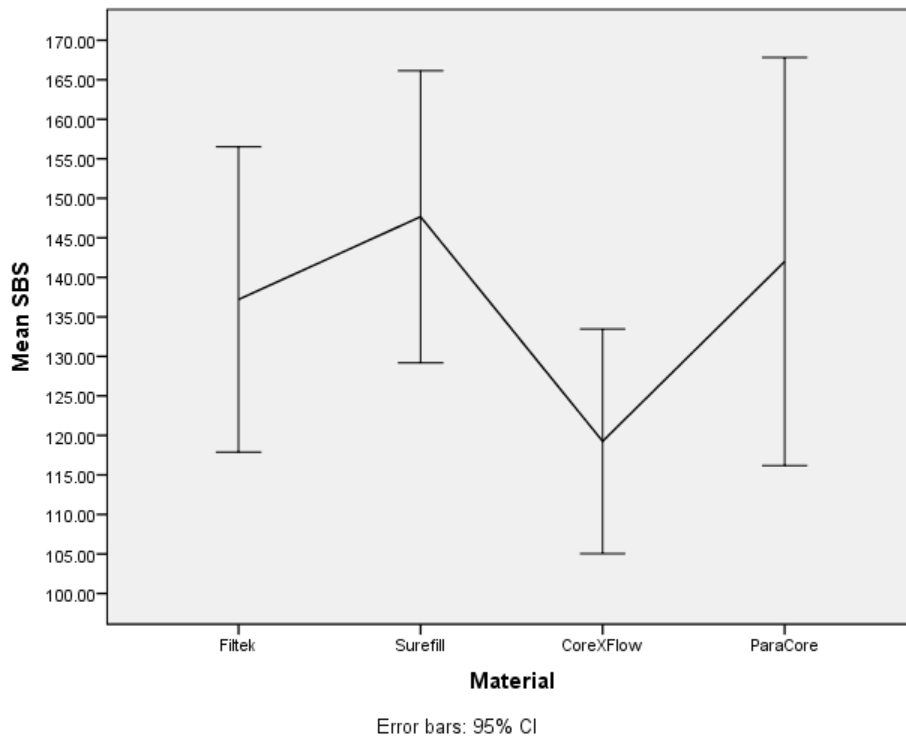


Figure 26: Means of strength with 95% CI per material.



Table 11: Pairwise comparison between materials

WESTERN CAPE

Dependent Variable: SBS						
(I) Material	(J) Material	Mean Difference (I-J)	Std. Error	Sig. ^a	95% Confidence Interval for Difference ^a	
					Lower Bound	Upper Bound
Filtek	Surefill	-10.467	12.627	1.000	-45.909	24.976
	CoreXFlow	17.950	13.036	1.000	-18.640	54.540
	ParaCore	-4.800	12.291	1.000	-39.297	29.697
Surefill	Filtek	10.467	12.627	1.000	-24.976	45.909
	CoreXFlow	28.417	13.354	.245	-9.066	65.899
	ParaCore	5.667	12.627	1.000	-29.776	41.109
CoreXFlow	Filtek	-17.950	13.036	1.000	-54.540	18.640
	Surefill	-28.417	13.354	.245	-65.899	9.066
	ParaCore	-22.750	13.036	.542	-59.340	13.840
ParaCore	Filtek	4.800	12.291	1.000	-29.697	39.297
	Surefill	-5.667	12.627	1.000	-41.109	29.776
	CoreXFlow	22.750	13.036	.542	-13.840	59.340

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Multiple comparisons were performed using the Pairwise comparisons test (Dunn-Sadak) to determine if there were any significant differences in flexural strength of the materials tested (Table 11). No significant difference in shear bond strength were found between the materials tested ($p>0.05$).

4.2.3. Mode of failure

The failure mode patterns were classified as two types:

Type 1: Cohesive failure in dentine

Type 2: Adhesive failure at luting-dentine interface

Table 12: Patterns of failures of different materials.

Material	Cohesive Failure %	Adhesive Failure%
ParaCore	25	75
CoreXflow	45	55
Filtek	30	70
SDR	60	40

ParaCore failed predominantly adhesively (75%) with the lowest cohesive failures (25 %). This was followed by Filtek which failed at 70 % cohesively. The highest cohesive failures were observed for SDR at 60 %. Whereas, CoreXflow showed an almost even distribution between the specimens failure patterns (Table 12).

CHAPTER 5

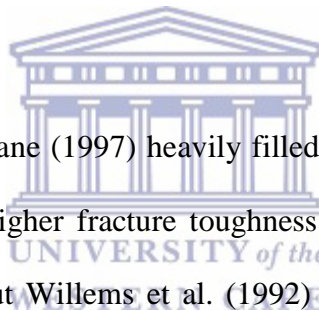
Discussion

A core build-up is a restoration placed to provide the foundation for a restoration that will endure the masticatory stress that occurs in the oral cavity for prolonged periods and to provide satisfactory strength and resistance to fracture before and after crown preparation in severely damaged teeth (Combe, *et al.*, 1999). The selection of materials is based primarily on ease of handling with due consideration being given for mechanical properties and manipulative variables. Among mechanical properties compressive strength of core materials is important because cores usually replace a large bulk of tooth structure and they should provide sufficient strength to resist intraoral compressive and tensile forces that are produced in function and parafunction (Anusavice, *et al.*, 2013). Flexural strength is used to evaluate the strength of the material and the amount of the distortion expected under bending stress (Anusavice, *et al.*, 2013). A core build up material must also exhibit good adhesion to dentine in the absence of micro-leakage, to prevent dislodgement of the restoration (Xie, *et al.*, 2008). Shear bond strength is greatly affected by a material's degree of polymerization shrinkage which influences its adhesion to dentine.

Under the conditions of the present study, there was a significant difference in flexural strength of the conventional restorative resin composite material that have been advocated as core materials (Filtek Supreme XTE & SDR Surefill) and those specifically designed as core build up materials (CoreXflow & ParaCore). These results reject the null hypothesis that there was no significant difference in the physical properties of these materials. The mean flexural strength (FS) was highest for CoreXflow followed by ParaCore although this was

statistically not significant. Similarly with the composite restorative group there was no significant difference between Filtek and SDR.

An ideal core build-up material should have physical properties similar to those of tooth structure, as a restored tooth tends to transfer stress differently than an intact tooth (Jain, *et al.*, 2015). Finan (2013) concluded his study by stating that the mechanical properties of composites are greatly influenced by alterations in their filler size and distribution of the filler. The filler component has a great influence on the dental composite's ability to resist crack initiation and propagation, as well as its response to abrasion and contact loading to wear.



According to Condon and Ferracane (1997) heavily filled composites have had higher wear resistance, higher strength and higher fracture toughness when compared with composites that have lower filler content, but Willems *et al.* (1992) pointed out that the filler content should not exceed 70%, because of technical difficulties and poor handling characteristics (Condon & Ferracane, 1997; Willems, *et al.*, 1992).

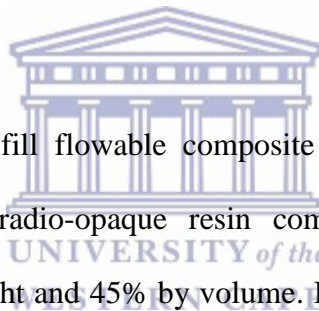
A study of dynamic fatigue using biaxial flexure testing revealed that composites with a broader distribution of filler particle sizes had a higher resistance to subcritical crack growth (Omaghi, *et al.*, 2012). A follow-up study by this group examined the fracture toughness, initial fracture strength and cyclic fatigue resistance of the same composites, and showed that the presence of larger particles led to enhanced fracture toughness owing to greater deflection energy-dissipating mechanisms (Omaghi, *et al.*, 2014). However, composites with smaller fillers had improve fatigue resistance owing to the fact that they were more creep compliant,

thus allowing them to dissipate lower load cyclic energy more efficiently. Thus composites with larger fillers would be expected to be more resistant to the rapid introduction of high contact forces, such as when teeth impact on one another or the patient bites down rapidly on a hard object, while those with smaller fillers would be superior under the conditions of lower cyclic stress, such as normal chewing. Although all the tested materials are indicated for core build-up according to the manufacturers their difference in flexural strength might be attributed to the differences in the composition of these materials.

ParaCore is a composite-based, dual-cured, radio-opaque material specifically designed for core build-up. ParaBond adhesive is a chemical cured, self-conditioning adhesive system for enamel and dentine. The technical data provided for ParaCore consists of average particle size: 2 μ m; Range of particle size: 0.1-5.0 μ m; Percentage by volume of total inorganic filler: approx. 50%; Percentage by weight of total inorganic filler: approx. 68%. Indications for use include: permanent cementation for all types of root canal posts, core build-ups and permanent cementation of crowns, bridges, inlays, onlays (ceramic, metal and composite) (Coltene, Switzerland, 2016).

CoreXflow consists of two-components, base and catalyst, which when mixed forms a dual-cured, highly filled, composite resin core build-up. The material contains UDMA, Di & tri-functional methacrylates and 69% fillers by weight. Indications for use include: vital or non vital tooth core build-up (replacement of existing restorations and/or lost tooth structure) as a base prior to fabricating an indirect restoration and cementation of endodontic fiber-posts (Dentsply, USA, 2016).

Filtek Supreme XTE is a visible light cured composite. The fillers are a combination of non-agglomerated/non-aggregated 20 nm silica filler, non-agglomerated/non-aggregated 4 to 11 nm zirconia filler, and aggregated zirconia/silica cluster filler (comprised of 20 nm silica and 4 to 11 nm zirconia particles). The material is classified as a nano-composite. The Dentin, Enamel and Body (DEB) shades have an average cluster particle size of 0.6 to 10 microns. The Translucent (T) shades have an average cluster particle size of 0.6 to 20 microns. The inorganic filler loading is about 72.5% by weight (55.6% by volume) for the translucent shades and 78.5% by weight (63.3% by volume) for all other shades. Indications for use include: direct anterior and posterior restorations (including occlusal surfaces), core build-ups, splinting and indirect restorations (including inlays, onlays and veneers) (3M ESPE, 2010).



SDR Flow is a posterior Bulk fill flowable composite that is one-component, fluoride-containing, visible light-cured radio-opaque resin composite restorative material. The Inorganic fillers are 68% by weight and 45% by volume. Indications for use include: base in cavity class I and II direct restorations, liner under direct restorative materials-class II box liner, pit and fissure sealant, conservative class I restorations and core Build-ups (Dentsply, USA, 2011).

The present study revealed a significant difference in flexural strength between the materials specifically designed for core build-up material namely ParaCore and CoreXflow and the 2 conventional composites namely Filtek Supreme XTE and SDR ($p < 0.05$). ParaCore had the higher mean flexural strength. Comparing the composition of the materials it is evident that there is a difference in the size and volume of their inorganic fillers (Table 13). The higher flexural strength values for ParaCore could be attributed to the smaller filler size; 0.1-.5 μ m

compared to Filtek Supreme XTE 0.6-1.4 μ m clusters. This according to Omaghi's study means that composites with smaller fillers would be superior under the conditions of lower cyclic stress, such as normal chewing because they have a greater fatigue resistance (Omaghi, *et al.*, 2014).

Table 13: Composite Core materials: Composition (Passos, et al., 2013).

CORE MATERIAL	RESIN & FILLER	SIZE	-VOL%	-WT%	BATCH #	MFG.
Filtek™ Supreme Plus (nanofilled) (<i>control group</i>)	UDMA, TEGDMA, BIS-EMA, inorganic fillers (silica nanofillers, zirconia/silica nanoclusters)	0.6 μ m to 1.4 μ m (cluster); 5 nm to 20 nm (particle); 20 nm (silica)	60%	79%	7BF	3M ESPE, Seefeld, Germany
ParaCore®, Dentin	methacrylates, barium glass, silica	0.1 μ m to 5 μ m	52%	74%	0118686	Coltène Whaledent Group, Mahwah, NJ, USA

Passos and colleagues (2013) also found that when comparing the fracture toughness (FT) of Filtek Supreme Plus and ParaCore, no significant difference was found. The FT was 1.53 MPa and 1.63 MPa for Filtek Supreme and Paracore respectively. The Diametral tensile strength of the two materials were also similar; Filtek Supreme: 40.5 MPa and ParaCore: 41.7 MPa; hence no significant difference (Passos, *et al.*, 2013). The previous study results could be attributed to the similarity in filler loading by weight.

ParaCore has also shown improved physical properties when compared to silorane-based material (Filtek TM 90). The silorane-based material (Filtek TM P90) showed the highest flexural strength, but other mechanical properties (compressive and tensile strength) were inferior to dual cure composite materials (LuxaCore and ParaCore) with nanofillers (Agrawal & Mala, 2014). ParaCore composite resin material showed excellent physical properties because it is reinforced with glass fibers; it is a dual cure material that will ensure complete cure, thereby improve the strength of the material. The macroscopic size of the unidirectional fiber bundles used in fiber reinforces the resins and improves their mechanical properties.

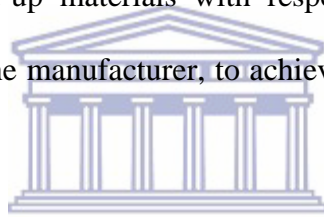
The presence of fibers affects the fracture process that results in interrupting crack growth progression and thus enhances the fracture toughness of the fiber-reinforced composite material (Coltene, Switzerland, 2016).

The mean flexural strength (FS) was highest for CoreXflow followed by ParaCore. The presence of urethane dimethacrylate (UDMA) in the resin matrix of CoreXflow may contribute to the superior mechanical properties (Zankuli, *et al.*, 2015). This was also supported by a previous study that reported that replacing bisphenol A-glycidyl methacrylate with UDMA resulted in improved flexural and tensile strength of resin composites (Tolosa, *et al.*, 2005). When compared to Bright Flow and Grandio Core, Core Xflow had significantly higher compressive strength because of its higher filler loading. The filler loading of Grandio Core and CoreXflow was higher than the other materials; and the fatigue strength of Grandio Core was significantly higher than CoreXflow due to the filler loading. Grandio Core has a filler weight loading of 77% compared to CoreXflow's 69 wt% (Zankuli, *et al.*, 2015).

The bulk fill flowable composite material Surefil® SDR (Smart Dentin Replacement)(Denstply, USA) flow contains a polymerization modulator, chemically embedded in the center of the polymerizable resin backbone of the SDR™ monomer, to lower polymerization shrinkage. De Biasi *et al.* (2010) investigated micro-hardness and raised concerns about its practical use due to its low Vickers hardness (HV). This was also confirmed by Ilie *et al.* (2011a) where Surefil® SDR™ flow showed the lowest surface hardness when compared to other commonly used RBCs (EsthetX Flow, Filtek Supreme Plus Flow, EsthetX Plus, Filtek Silorane, and Filtek Supreme Plus). A recent study also found that the mechanical properties of the bulk-fill low viscosity flowable composites were mostly lower compared with the conventional high viscosity material, and, at best, comparable to the

conventional flowable composite. Given the lower mechanical properties of most bulk-fill materials compared to a highly filled nano-hybrid composite, their use for restorations under high occlusal load is subject to caution. (Leprince, *et al.*, 2014).

The major disadvantage of composite resins is that the materials undergo polymerization shrinkage, resulting in the release of stresses, which ultimately affects the materials shear bond strength, volumetric stability and its mechanical properties (Oliva & Lowe, 1987). Bond strength values are gross assessing tools for evaluating the efficacy of bonding restorative materials to dentin. Of the various tests the shear bond strength is less technique sensitive to perform, highlighting the strength of the bonded interface. This study compared the SBS of four composite resin core build-up materials with respective dentine bonding adhesives provided and recommended by the manufacturer, to achieve the maximum effect of bonding procedure (Table 5).



The present study was done in-vitro, as the clinical functions and characteristics of dental materials are difficult to evaluate under in-vivo conditions, and clinical trials cannot estimate mechanical properties of restored teeth (Petronijevic, *et al.*, 2012). Whereas in-vitro tests gives the possibility to evaluate mechanical properties of restored teeth and is considered as a predictor of the possible clinical performance of the material (Cohen, *et al.*, 1997).

The coronal surface was used to evaluate SBS as previous studies have shown that a reduction in bond strength occurs when resin composites are bonded to deep dentin (Srinivasulu, *et al.*, 2012) which can be attributed to the complexities in the structure of deep dentin, such as increase in the number of tubules and their diameters with much lesser intertubular dentin matrix as compared to superficial dentin (Tagami & Pashley, 1990).

This study made use of healthy incisor teeth with intact dentin because it was previously shown that restored incisors with carious-affected dentin may lower fracture resistance than healthy incisor teeth (Erhardt, *et al.*, 2008). Yoshiyama et al (2002) have found that many specimens of resin—bonded caries-affected dentin failed cohesively in dentine. This did not occur in normal dentine, where the bonds failed adhesively (Yoshiyama, *et al.*, 2002). This was confirmed by Markovic and colleagues (2011) that found that caries affects the bond strength of the restorative material and dentine and leads to lower mechanical properties of the restored teeth.

In the present study the mean Shear Bond Strength (SBS) was highest for SDR Surefill followed by ParaCore. The Mean SBS values for SDR Surefill, ParaCore, Filtek Supreme XTE and CoreXflow, obtained were 147.6 N, 142 N, 137 N, 119.2 N respectively. However no statistical significance difference in shear bond strength were observed between all materials tested including a good bond between all cements bonded to tooth structure (Dunn-Sadak; $p>0.05$).

Shear bond strength is greatly affected by a material's degree of polymerization shrinkage which influences its adhesion to dentine. The amount of intact dentine also affects the bond strength of the material (Markovic, *et al.*, 2011). Polymerization shrinkage is related to the organic and inorganic content of the composite resins. Flowable composites generally contain more organic matrix in order to gain increased flow. Thus, they have greater shrinkage compared to hybrid composites, which have less organic matrix (Correa, *et al.*, 2010). All materials were used in increments of 2 mm to counter act any shrinkage that may occur.

The fluidity of flowable composites allows it to act as shock absorbers, which counter acts any polymerization stresses (Dietschie, et al., 2003; Li, *et al.*, 2006). The bulk fill material Surefil® SDR™ flow contains a polymerization modulator, chemically embedded in the center of the polymerizable resin backbone of the SDR™ monomer, to lower polymerization shrinkage. Investigations on RBCs with SDR™ technology showed significant lower shrinkage stress values (Burgess & Cakir, 2010) not only when compared to regular flowable RBCs, but also to nano- and hybrid RBCs or even to silorane-based composites (Ilie & Hickel, 2011a).

CoreXflow is also a flowable composite that has proven to be successful when used with its XP bonding system around fiber reinforced posts. The material demonstrated good bond strength and minimal nanoleakage (Mazzoni, *et al.*, 2009). However the literature fails to produce any studies on the shear bond strength of CoreXflow without the use of a post.



Various dual-cured resin composite build-up restoratives that combine the advantages of light curing and self curing mechanisms have been introduced, with the rationale to develop a material capable of reaching higher degree of polymerization in either the presence or absence of light, and overcome the limitations of reduced interlayer strength (Kournetas, et al., 2011). In a recent study comparing the shear bond strength of 3 dual-cure core build-up materials; Multi-Core dual-cure resin based core build-up material showed the highest mean SBS as compared to FluoroCore and ParaCore. SBS was not negatively affected by thermocycling (Jain, *et al.*, 2015), hence the studied specimens were not thermocycled prior to shear bond tests.

Both the ParaCore and Filtek adhesives (Table 5) contain ethanol as an organic solvent in the bonding agent. A previous study has shown that ethanol does not chase water due to its high boiling temperature and less vapour pressure as opposed to acetone adhesives which could efficiently remove surface water and increase vapour pressure (Nair, *et al.*, 2014). Thus this can adversely affect the material's shear bond strength.

All the materials showed good adhesion to the tooth structure. ParaCore displayed the most adhesive failures at 75% followed by Filtek at 70%. This could be possibly be due to the presence of ethanol contain in their adhesive composition. SDR displayed the highest cohesive failures at 60% followed by CoreXflow at 45 %. These results could be due to both materials making use of XP Bond as an adhesive. Which have shown to display good bond strength and minimal nanoleakage (Mazzoni, *et al.*, 2009).



CHAPTER 6

Conclusions and recommendations

6.1. Conclusions

In the present study the composite core materials specifically designed as core build up materials displayed a greater flexural strength compared to the conventional restorative composites used as core materials. A significant difference was found in the flexural strength of these materials. The physical properties of composites are greatly enhanced by alterations in their filler size and distribution of the filler. The filler component has a great influence on the dental composite's ability to resist crack initiation and propagation, as well as its response to abrasion and contact loading leading to wear. The smaller filler sizes and greater filler loading of CoreXflow and ParaCore have shown to increase the flexural strength of these materials thus making them more superior for the use as core build-up material compared to conventional restorative composites.

No significant difference was found when the shear bond strength of these materials was compared. This could be attributed to the composition of the core materials as well as the composition of the various adhesive systems used. There was good adhesion of all the materials to the tooth structure.

6.2. Recommendations

Various conventional restorative composite materials are being indicated as core materials however these materials physical properties might not be adequate for use as core-build up materials. When selecting a core material is important to have the knowledge of the composition of the material as well as the adhesive systems recommended by the manufacturer.

An ideal core build-up material should have physical properties similar to that of tooth structure, as a restored tooth tends to transfer stress differently than an intact tooth. Flexural and shear bond strengths of core materials are thought to be important because cores usually replace a large bulk of tooth structure and must resist multidirectional masticatory forces for many years. The core material should have flexural strength to prevent core dislodgement during function. Shear bond strength of a core material is a crucial property that will determine the ultimate suitability of a material to be advocated clinically. Several dental materials have been used for core build-up procedures although not specifically designed for core build-up. The knowledge of the material's physical properties will ultimately determine their selection as core build-up material. Even though a material is indicated as core build-up material does not necessarily mean that the material's strength is adequate to resist forces during function or mastication.

6.3. Limitations of study

The present study was done in-vitro, as the clinical functions and characteristics of dental materials are difficult to evaluate under in-vivo conditions, and clinical trials cannot estimate mechanical properties of restored teeth. In-vitro tests give the possibility to evaluate mechanical properties of restored teeth and could be considered as a predictor of the possible

clinical performance of the material. Clinically other factors such as moisture control and masticatory load can affect the results of the current study.



CHAPTER 7

References

- Agrawal, A. & Mala, K., 2014. An in vitro comparative evaluation of physical properties of four different types of core materials. *Journal of Conservative dentistry*, 17(3), pp. 230-233.
- Ahrahlah, A., Silikas, N. & Watts, D., 2014. "Post-cure depth of cure of bulk-fill dental resin composites". *Dental Materials*, Volume 30, pp. 149-154.
- Anusavice, K., Shen, C. & Rawls, H., 2013. *Phillips's science of dental materials*. 12 ed. St. Louis: Elsevier.
- Armstrong, S., Geraldeli, S. & Rodigo, M., 2010. Adhesion to tooth structure: A critical review of "micro" and "macro" bond strength test methods. *Dental Materials*, Volume 26, pp. e50-e62.
- Bayindir, Y., 2007. Comparison of diametral tensile, flexural, and compressive strengths of five core build-up materials. *Atatürk Üniv. Di*, pp. 18-28.
- Bayne, S., Heymann, H. & Swift, E., 1994. Update on dental composite restorations. *Journal of American Dental Association*, Volume 125, pp. 687-701.
- Bayne, S., Thompson, J. & Swift, E., 1998. A characterization of first-generation flowable composites. *J Am Dent Assoc*, 129(5), pp. 567-77.
- Bonilla, E., Mardirossian, G. & Caputo, A., 2000. Fracture toughness of various core build-up materials. *Journal of prosthodontics*, Volume 9, pp. 14-18.
- Bonilla, E., Yashar, M. & Caputo, A., 2003. Fracture toughness of nine flowable composites.. *The journal of prosthetic dentistry*, Volume 89, pp. 216-267.
- Burgess, J. & Cakir, D., 2010. Comparative properties of low-shrinkage composite resins. *Compend Cont Educ Dent*, Volume 31, pp. 10-15.
- Burke, F., Hussain, A. & Nolan, L., 2008. Methods uses in dentine bonding tests: a analysis of 102 investigations on bond strength. *European Journal of Prosthodontic Restorative Dentistry*, Volume 16, pp. 158-65.
- Celik, C., Ozgunaltay, G. & Attar, N., 2007. Clinical evaluation of flowable resins in non-carious cervical lesions: two-year results. *Operative Dentistry*, Volume 32, pp. 313-321.
- Chen, M., 2010. Update on dental naocomposites. *Journal of Dental Restoratives*, Volume 89, pp. 549-60.
- Choi, K., Ferracane, J. & Hilton, T., 2000. Properties of packable dental composites. *Journal of Esthetic Dentistry*, Volume 12, pp. 216-26.

Christensen, G., 2012. Advantages and challenges of bulk-fill resins. *Clinical Report*, Volume 5, pp. 1-2.

Christensen, R., 2000. Building up tooth preparations for full crowns-2000. *Journal of American Dental Association*, Volume 131, pp. 205-506.

Chung, C., Kim, J. & Kim, K., 2002. Development of a new photocurable composite resin with reduced curing shrinkage. *Dental Materials*, Volume 18, pp. 174-178.

Chutinan, S., Platt, J. & Cochran, M., 2004. Volumetric dimensional change of six core materials. *Dental Materials*, Volume 20, pp. 345-351.

Cobb, D., MacCregor, K. & Vargas, M., 2000. The physical properties of packable and conventional posterior resin-based composites: a comparison. *Journal of American Dental Association*, Volume 131, pp. 1610-1615.

Cohen, B., Pagnillo, M. & Deutsch, A., 1997. Fracture strength of three core restorative materials supported with or without a prefabricated split-shank post. *Journal of Prosthetic dentistry*, Volume 78, pp. 560-5.

Coltene., 2016. Coltene/Whaledent Technical Specifications. <http://nam.coltene.com>

Combe, E., Shaglouf, A. & Watts, D., 1999. Mechanical properties of direct core materials. *Dental Materials*, Volume 15, pp. 158-165.

Condon, J. & Ferracane, J., 1997. In vitro wear of composite with varied cure, filler level and filler treatment. *J Dent Res*, Volume 76, pp. 1405-1411.

Correa, M., Henn, S. & Marimon, J., 2010. Factors influencing the microhardness of a microhybrid composite. *General Dentistry*, Volume 58, pp. e94-e98.

Craig, R. & Powers, J., 2002. *Restorative Dental Materials*. 11 ed. St. Louis: Mosby Inc.

Curtis, A., Palin, W. & Fleming, G., 2009. The mechanical properties of nanofilled resin-based composites: the impact of dry and wet cyclic pre-loading on bi-axial flexural strength. *Dental materials*, Volume 25, pp. 188-97.

Czasch, P. & Ilie, N., 2013. In vitro comparison of mechanical properties and degree of cure of bulk fill composites. *Clinical Oral Investigations*, Volume 17, pp. 227-235.

Davidson, C., de Gee, A. & Feilzer, A., 1984. The competition between the composite-dentine bond strength and the polymerization contraction stress. *Journal of Dental Restorations*, Volume 63, pp. 1396-1399.

de Biasi, M., Calvi, R. & Sossi, D., 2010. Microhardness of a new flowable composite liner for posterior restorations. *Dental Materials*, Volume 26, pp. e25-e25.

Dentsply., 2011. Dentsply Technical Specifications. <http://www.dentsply.com>

Dentsply., 2016. Dentsply Technical Specifications. <http://www.dentsply.com>

Dietschie, D., Olsburgh, S. & Davidon, C., 2003. In vitro evaluation of marginal and internal adaptation after occlusal stressing of class II composite restorations with different resinous bases. *European Journal of oral science*, Volume 111, pp. 73-80.

Dogon, L., 1990. Present and future value of dental composite materials and sealant. *Int J Technol*, Volume 6, pp. 369-377.

El-Nawawy, M., Koaitim, L. & Abouelatta, O., 2012. Depth of cure and microhardness of nanofilled, packable and hybrid composite resins. *American journal of biomedical engineering*, Volume 2, pp. 214-250.

El-Safty, S., Silikas, N. & Watts, D., 2012. Creep deformation of restorative resin-composites intended for bulk-fill placement. *Dental Materials*, Volume 28, pp. 928-935.

Emami, N., Soderholm, K. & Berglund, L., 2003. Effect of light power density variations on bulk curing properties of dental composites. *J Dent*, Volume 31, pp. 189-196.

Erhardt, M., Toledano, R. & Osono, L., 2008. Histomorphological characterization and bond strength evaluation of carriers affected dentin/resin interfaces: Effects of long term water exposure. *Dental Materials*, Volume 24, pp. 786-796.

Ernst, C., Bradenbusch, M. & Meuer, G., 2006. Two-year clinical performance of a nanofiller vs a fine-particle hybrid resin composite. *Clinical Oral Investigations*, Volume 10, pp. 119-25.

Ernst, C., Canbank, K. & Aksoy, K., 2003. Two-year clinical performance of a packable posterior composite with and without a flowable composite. *Clinical Oral Investigations*, Volume 7, pp. 123-128.

Estafan, D. & Agosta, C., 2003. Eliminating microleakage from the composite resin system. *General Dentistry*, Volume 51, pp. 506-509.

Feilzer, A., de Gee, A. & Davidson, D., 1987. Setting stress in composite resin in relation to configuration of the restoration. *Journal of Dental Research*, Volume 66, pp. 1636-1639.

Ferracane, J., 2011. "Resin composite-state of the art". *Dental materials*, 27(1), pp. 29-38.

Ferracane, J., Pfeifer, C. & Hilton, T., 2014. Microstructural features of current Resin composite materials. *Current Oral Health Reports*, Volume 1, pp. 205-212.

Finan, L., Palin, W. & Moskwa, N., 2013. The influence of irradiation potential on the degree of conversion and mechanical properties of two bulk-fill flowable RBC base materials. *Dental Materials*, 29(8), pp. 906-912.

Fortin, D. & Vargas, M., 2000. The spectrum of composites: new technology and materials. *Journal of American Dental Association*, Volume 131, pp. 26S-30S.

Gallato, A., Angnes, G. & Reis, A., 2005. Long-term monitoring of microleakage of different amalgams with different liners. *The Journal of Prosthetic Dentistry*, 93(6), pp. 571-576.

Garcia, A., Lozano, M. & Vila, J., 2006. Composite resins. A review of the materials and clinical indications. *Med Oral Patol Oral Cir Bucal*, 11(2), pp. 215-220.

Garcia, D., Yaman, P. & Dennison, J., 2014. Polymerization shrinkage and depth of cure of bulk fill flowable composite resins. *Operative Dentistry*, 39(4), pp. 441-448.

Han, L., Ishizaki, H. & Fukushima, M., 2009. Morphological analysis of flowable resins after long-term storage or surface polishing with a mini-brush. *Dental Materials*, Volume 28, pp. 277-284.

Ilie, N., Bucuta, S. & Draenert, M., 2013. Bulk-fill resin-based composites: An in vitro assessment of their mechanical performance. *Operative dentistry*, Volume 38, pp. 618-628.

Ilie, N. & Hickel, R., 2009a. Investigations on mechanical behavior of dental composites. *Clinical Oral Investigations*, Volume 13, pp. 427-38.

Ilie, N. & Hickel, R., 2009b. Macro-, micro- and nano-mechanical investigations on silorane and methacrylate-based composites. *Dental Materials*, Volume 25, pp. 810-9.

Ilie, N. & Hickel, R., 2011a. Investigations on a methacrylate-based flowable composite based on SDR technology. *Dental Materials*, Volume 27, pp. 384-355.

Ilie, N. & Hickel, R., 2011b. Resin composite restorative materials. *Australian dentall journal*, Volume 56, pp. 59-66.

Jain, G., Narad, A. & Boruah, L., 2015. Comparative evaluation of shear bond strength of three resin dual-cure core build-up materials: An in-vitro study. *Journal of conservative dentistry*, 18(14), pp. 337-341.

Kanchanasavita, W., Anstice, H. & Peatson, G., 1998. Long-term flexural strength of resin-modified glass-ionomer cements. *Biomaterial*, Volume 19, pp. 1703-1713.

Klein, F., Keller, A. & Stawhle, H., 2002. Proximal contact formation with different restorative materials and techniques. *American Journal of Dentistry*, Volume 15, pp. 232-235.

Kournetas, N., Tzoutzas, I. & Eliades, G., 2011. Monomer conversion in dual-cured core buildup materials. *Operative Dentistry*, Volume 36, pp. 92-7.

Kramer, N., Reinelt, C. & Richter, G., 2009. Nanohybrid vs. fine particle composite in class II cavities: clinical results and margin analysis after four years. *Dental Materials*, Volume 25, pp. 750-9.

Land, M. & Rosenstiel, S., 2006. *Contemporary Fixed Prosthodontics*. 4 ed. Elsevier: Mosby.

Leinfelder, K., Bayne, S. & Swift, E., 1999. "Packable composites: Overview of technical considerations". *Journal of Esthetic and Restorative Dentistry*, Volume 5, pp. 234-249.

Leloup, G., D'Hoore, W. & Bouter, D., 2001. Meta-analytical review of factors invlved in dentin adherence. *Journal of Dental Restoratives*, Volume 80, pp. 1605-14.

Leprince, J., Palin, W. & Vanacker, J., 2014. Physico-mechanical characteristics of commercially available bulk-fill composites. *Journal of dentistry*, Volume 42, pp. 993-1000.

Li, Q., Jepsen, S. & Albers, H., 2006. Flowable materials as a intermediate layer could improve the marginal and internal adaptation of composite restorations in Class V cavities. *Dental Material*, Volume 22, pp. 250-257.

Loguercio, A., Zago, C. & Leal, K., 2005. One-year clinical evaluation of a flowable resin liner associated with a microhybrid resin in noncarious cervical lesions. *Clinical Oral Investigations*, Volume 9, pp. 18-20.

Lopes, L., Cefaly, D. & Fanco, E., 2003. Clinical evaluation of two "packable" posterior composite resins: two year results. *Clinical Oral Investigations*, Volume 7, pp. 123-128.

Lutz, F. & Phillips, R., 1983. A classification and evaluation of composite resin systems. *Journal of Prosthetic Dentistry*, Volume 50, pp. 480-488.

3M ESPE., 2010. 3M ESPE Technical Product Profile. multimedia.3m.com

Manhart, J., Kunzelmann, K. & Chen, H., 2000. Mechanical properties and wear behavior of light-cured packable composite resins. *Dental Materials*, Volume 16, pp. 33-40.

Markovic, D., Petronijevic, B. & Blazic, L., 2011. Bond strength comparison of three core build-up material used to restore maxillary incisor teeth. *Contemporary materials*, II(1), pp. 62-68.

Masouras, K., Silikas, N. & Watts, D., 2008. Correlation of filler content and elastic properties of resin composites. *Dental Materials*, Volume 24, pp. 932-939.

Mazzoni, A., Marchesi, G. & Cadenaro, M., 2009. Push-out stress for fibre posts luted using different adhesive strategies. *European journal of oral science*, Volume 117, pp. 447-453.

Mc Cabe, J., 1998. Resin-modified glass ionomer cements. *Biomaterials*, Volume 19, pp. 521-527.

Meiers, J. & Turner, E., 1998. Microleakage of dentin/amalgam alloy bonding agents: results after 1 year. *Operative Dentistry*, Volume 23, pp. 30-5.

Nair, M., Kumur, S. & Chakravarthy, Y., 2014. Comparative evaluation of the bonding efficacy of sixth and seventh generation bonding agents: An in-vitro study. *J Conservative Dent*, Volume 17, pp. 27-30.

Nomoto, R., Asada, M. & Mc Cabe, J., 2006. Light exposure required for optimum conversion of light activated resin systems. *Dental Material*, Volume 22, pp. 1135-1142.

- Nujella, B., Choudary, M. & Reddy, S., 2012. Comparison of shear bond strength of aesthetic restorative materials. *Contemporary Clinical Dentistry*, 3(1), p. 22.
- Oliva, R. & Lowe, J., 1987. Dimensional stability of silver amalgam and composite used as core material. *Journal of prosthetic dentistry*, Volume 57, pp. 554-9.
- Omaghi, B., Meier, M. & Rosa, V., 2012. Subcritical crack growth and in vitro lifetime prediction of resin composites with different filler distribution. *Dental Materials*, 28(9), pp. 985-95.
- Omaghi, B., Meier, M. & Rosa, V., 2014. Fracture toughness and cyclic fatigue resistance of resin composites with different filler size distributions. *Dental Materials*, 30(7), pp. 742-51.
- Ozel, E., Korkmaz, Y. & Attar, N., 2008. Effect of one-step polishing systems on surface roughness of different flowable restorative materials. *Dental Materials*, Volume 27, pp. 755-764.
- Passos, S., Freitas, A. & Jumaily, S., 2013. Comparison of mechanical properties of five commercial dental core build-up materials. *Compendium*, 34(1), pp. 62-68.
- Perdigao, J., Geraldini, S. & Lee, K., 2004. Push-out bond strengths of tooth-colored posts bonded with different adhesive systems. *American journal of dentistry*, Volume 17, pp. 422-426.
- Petronijevic, B., Markovic, D. & Sarcev, I., 2012. Fracture resistance of restored maxillary premolars. *Contemporary Materials*, III(2), pp. 219-225.
- Peumans, M., Merbeek, B. & Asscherick, K., 2001. Do condensable composites help to achieve better proximal contacts. *Dent Materials*, Volume 17, pp. 533-541.
- Puckett, B., Fitchie, J. & Chatterjee, K., 2007. Direct composite restorative materials. *Dental Clinics of North America*, Volume 51, pp. 659-675.
- Ravi, R., Alla, R. & Shamma, M., 2013. Dental Composites-A Versatile Restorative Material: An Overview. *Indian Journal of Dental science*, Volume 5, pp. 11-115.
- Saygili, G. & Sahmali, S., 2002. Comparative study of the physical properties of core materials. *International Journal Periodontics Restorative Dentistry*, Volume 22, pp. 355-363.
- Shillingburg, H., Hobo, S. & Whitsett, L., 1997. *Fundamentals of Fixed Prosthodontics*. 3 ed. St. Louis: Quint Publishing Co.
- Srinivasulu, S., Vidhya, S. & Sujatha, M., 2012. Shear bond strength of composite to deep dentine after treatment with two different collagen cross-linking agents at varying time intervals. *Operative Dent*, Volume 37, pp. 485-91.
- Sturdevant, J., Bayne, S. & Wilder, A., 1993. 3-Year clinical study of a failed condensable posterior composite. *Journal of Dental Restoratives*, Volume 72, p. 380.

Tagami, J. & Pashley, D., 1990. Correlation among dentin depth, permeability, and bond strength of adhesive systems. *Dental Materials*, Volume 6, pp. 45-50.

Thomsen, K. & Peutzfeldt, A., 2007. Resin Composites: strength of the bond to dentine versus mechanical properties. *Clinical Oral Investigations*, Volume 11, pp. 45-9.

Tolosa, M., Paulillo, L. & Giannini, M., 2005. Influence of composite restorative materials and light-curing units on dimetrical tensile strength. *Brazilian Oral Research*, 19(2), pp. 123-126.

Van Meerbeek, B., Peumans, M. & a., P., 2010. Relationship between bond strength test and clinical outcomes. *Dental Materials*, Volume 26, pp. e100-e121.

Van Noort, R., 2002. *Introduction to dental materials*. 2 ed. St. Louis: Mosby Inc.

Walmsley, A., Walsh, T. & Burke, F., 2002. *Restoration of teeth (Complex Restorations)*. Churchill: Livingstone.

Wassell, R., Smart, E. & George, G., 2002. Crowns and extra coronal restorations: Cores for teeth with vital pulps. *British dental Journal*, Volume 192, pp. 499-509.

Willems, G., Lambrechts, P. & Bream, M., 1992. A classification of dental composites according to their morphological and mechanical characteristics. *Dental Materials*, Volume 8, pp. 310-319.

Xie, H., Zhang, F. & Wu, Y., 2008. Dentine bond strength and microleakage of flowable composite, compomer and glass ionomer cement. *Australian Dental Journal*, Volume 53, pp. 325-331.

Yap, A., Low, J. & Ong, L., 2000. Effect of food-stimulating liquids on surface characteristics of composite and poly-acid composite restoratives. *Operative Dentistry*, Volume 25, pp. 170-176.

Yoshiyama, F., Tay, R. & Doi, J., 2002. Bonding of self-etch and total-etch adhesives to carious dentin. *Journal of dental research*, Volume 81, pp. 556-560.

Zankuli, M., Silikas, N. & Devlon, H., 2015. The effect of cyclic-loading on the compressive strength of core build-up materials. *Journal of prosthodontics*, Volume 24, pp. 549-552.

Zimmerli, B., Strud, M. & Jeger, F., 2010. Composite Materials: composition, properties and clinical applications: A literature review. *Schweizer Monatsschrift fur Zahnmedizin*, 120(11), pp. 972-986.

Ziskind, D., Venezia, E. & Kreisman, I., 2003. Amalgam type, adhesive system, and storage period as influencing factors on microleakage of amalgam restorations. *Journal of Prosthetic Dentistry*, Volume 90, pp. 255-60.

Chapter 8

Appendix

Appendix 1: Patient Information Sheet

Oral & Dental Research Institute

Faculty of Dentistry and WHO Oral Health Collaborating Centre

University of the Western Cape

Cape Town

Patient Information Sheet to be given to the patient to take home

I, Dr Winifred Asia am a qualified dentist involved in research and training at the University of the Western Cape, Faculty of Dentistry.



I am doing research on how well new composite restorative materials adhere to tooth structure.

After the removal of your maxillary incisor tooth, they will be either discarded or given to the students to practice on. I wish to use your extracted teeth to be able to determine which restorative material has the greatest adhesion to the tooth structure in the laboratory.

Donating your tooth to the study is on a voluntary basis. Donating your tooth for this study or refusing to participate will not harm or prejudice you in any way. The tooth supplied to me will not have your name on it as well as I will not be able to identify you in any way. Upon completion of the study the teeth will be discarded or given to the students to practice on.

Participating in the study will definitely benefit future studies and will add to our existing pool of knowledge. All information will be kept strictly confidential.

Thanking you.

-----,

Dr. Winifred Asia

Researcher

Oral & Dental Research Institute

Oral Health Centre Tygerberg

Contact details: Tel: (021) 937 3170

Mobile: 078 000 7239

I, (Patient name)....., fully understand the
information supplied to me by Dr Winifred Asia in this information sheet.



Signature:

Date: