ORIGINALRESEARCH

EvaluationofCompressiveandFlexuralStrengthsofTwoResin-basedCoreMaterialswithanAlkasiteMaterial: An*InVitro*Study

Abstract

Aim: To compare and evaluate the compressive and flexural strengths of two resin-based core build-up materials with an alkasite material.**Materialsandmethods:**ParaCore,TetricNceramBulk-fillcomposite,andCentionNwereused.Atotalof90specimenswereprepared.Customizedcylindricalsplitmoldsofdimension6±1mm(height)×4±1mm(diameter)wereusedtofabricate15samplesofeachcorematerialfortestingthecompressivestrengthandrectangularsplitmetalmoldsofdimensions25±1mm(length)×2±1mm(width)×2±1mm(height)wereusedtofabricate15samplesofeachcorematerialfortestingtheflexuralstrength.ThenthesamplesweretestedusingaUniversaltesting machine(UTM).

Results: ThecompressiveandflexuralstrengthsofCentionNweresignificantlylessthanParaCore®buthigherthanTetric®N-Ceram™Bulk-fillcorebuild-upmaterial.

Conclusion: Withinthelimitationsofthisstudy,itwasconcludedthatCentionNmaybeusedasanalternativetoothercorebuild-upmaterialsafterfurther*in-vitro*and*in-vivo*studies.

Clinicalsignificance: CentionNhadtheaddedadvantagethatself-curepolymerizationalonewassufficienttoachievegoodphysicalpropertieswhencomparedtotheothertworesin-basedcorebuild-upmaterials.

Keywords: Alkasite,CentionN,Corebuild-upmaterials.

Introduction

Prostheticrehabilitationofrootcanal-treatedteethwithinadequatestructure poses a challenge to Prosthodontists'. Biologic, esthetic,and functional demands have to be met while ensuring theretention and stability of subsequent prosthetic restorations. Acorebuild-uprestorationisindicatedwhentheremainingcoronaltooth structure is not sufficient to create retention and resistancefor crown and bridge restorations. The core material should havecompressivestrengthtoresistintraoralforcesandflexuralstrength to prevent dislodgement during function. Composites, resins,glass ionomer, cast metal alloy, and dental amalgam have beenrecommended for coronal build-up after completion of root canaltreatment.[1,2]

Several dental materials have been used for core build-upprocedures, some as direct and some as indirect, such as a customcast post and core. The material used for direct core build-up wasnotspecificallydevelopedforthispurposebutdidfindapplications incorebuild-upduetopropertiessuchasfluoriderelease,adhesion tothetoothstructure,choiceofcuringmechanism,andbetter handling properties to name a few. Each of these materials has itsadvantages and disadvantages, a thorough knowledge of whichhelps in the selection of the appropriate material for a particularclinicalsituation.[3]

Variousversionsofresincompositebuild-upmaterialslikeTetricNCeramandParaCore™havebeenintroduced witharationaletodevelop a better material to overcome the limitations of previousmaterials. Tetric N Ceram Bulk-fill contains bisphenol A-diglycidyldimethacrylate(Bis-GMA),ethoxylatedbisphenoladimethacrylate (Bis-EMA),andurethanedimethacrylate(UDMA).Itrepresents themediumviscositytypeBulk-fill.Thecuringdepthof4mmisachieved mainly due to the patented photo-initiator, Ivocerin,whichisfarmorereactivethanconventionalinitiators.[4]ParaCore is a dual-cured, glass-reinforced, radiopaque composite systemavailable in three shades. The material simplifies the post andcore restorative technique because it is ideal for post-cementationas well as core-build-ups. It exhibits a stackable, non-slumpyconsistencyandisformulatedtocutsimilarlytodentin,allowing

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Add P value to the results
How many specimens were analyzed? Did all 90 samples undergo a universal testing machine?
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Comment [FH2]: The font needs to be the same

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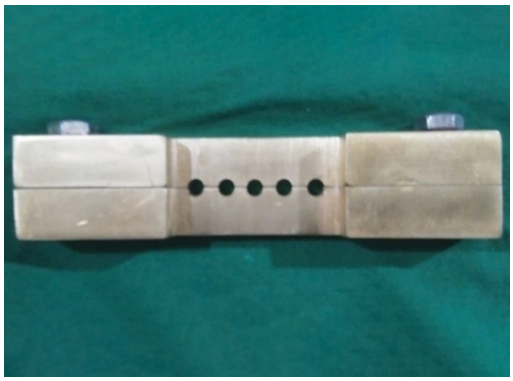

Fig.1: Cylindricalbrassmold

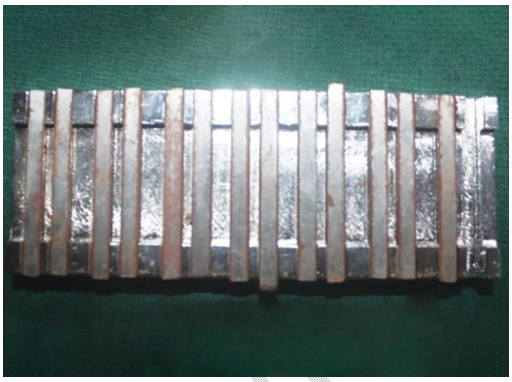

Fig.2: Rectangularmetalmold

theburtomovesmoothlybetweenthenaturaltoothstructureandthe material without creating troughs and grooves. It incorporatesglassparticlesthatimparthighstrength.[5]CentionNisare centlyintroducedesthetic,resin-basedBulk-fillingmaterial.Itisanalkasiterestorative material that is essentially a subgroup of the compositematerial class and utilizes an alkaline filler that is capable ofreleasing acid-neutralizing ions like fluoride, calcium, and hydroxylions.[6,7]CentionNisaself-curerestorativematerialthatcanalsobepolymerized with a light cure.[8]The purpose of this study was toevaluatetheefficacyofthenewlyintroducedmaterialCentionNasa core build-up material. The aim and objective of this study weretocompareandevaluatethecompressiveandflexuralstrengths ofTetric®N-Ceram™Bulk-fillcomposite,ParaCore™,CentionN.

MaterialsandMethods

This study was approved by the Institutional Review Board andconductedintheDepartmentofProsthodonticsandCrown&Bridgeat MaheInstituteofDentalSciences,MahefromMarch2020toSeptember2020.

SamplePreparation

Threecommerciallyavailablecorebuild-upmaterialswereused.Thespecimendimensionsforeachpropertywereselectedaccordingto International Standards Organization (ISO) 4049 (ISO, 1992). A totalof 90 specimens were fabricated with 30 samples of each type ofcorematerialnamelyTetricNceramBulk-fillcomposite,ParaCore™andCentionN.Thespecimendimensionsfor eachpropertywereselectedaccordingtoInternationalStandardsOrganization(ISO)4049(ISO,1992).Acustom-madecylindricalsplitbrassmold(Fig.1)of dimensions 6 ± 1 mm (height) × 4 ± 1 mm (diameter) wasused to fabricate 15 samples of each core material for testing thecompressive strength and custom-made rectangular split metalmolds(Fig.2)ofdimensions25±1mm(length)×2±1mm(width) ×2±1mm(height)wereusedtofabricate15samplesofeachcorematerialfortestingtheflexuralstrength.

Thelightcuredmaterials(Bulk-fill&ParaCore™)werepackedin2 mm layers to fill the mold and the excess material was removed.Thespecimenswerepolymerizedusingabluelight-emittingdiodelightsourcefor40secondsperlayer.Thetipofthelightsourcewasheldwithin3mm–

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If this chapter is according to a published article then it is fine. But if this is a not published manuscript, I would like the authors to explain the 4 years gap.

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Fig.3: Universaltestingmachine

the mold and inspected for voids, and those with voids or otherdefects were discarded. To have complete curing, each specimenwaspost-cured10minutesafterremovalfromthemoldfor60 seconds from all directions to ensure a good polymerizationdepth.Thespecimenswerestoredindistilledwaterat37±1°Cfor24 hours prior to testing. Cention N consists of a separatelypackaged powder and liquid those are mixed by hand directlybefore use. One scoop of powder is used per one drop of liquid,correspondingtoapowder/liquidweightratioof4.6–1Itwasthen loadedintothemold,tightlypacked,andlightcuredfor20secondswith LED curing light (woodpecker).[9]Each cylindrical specimen wasattachedtoabasewhichwasmadewithself-cureclearacrylicresinofheightandwidthof2cm.Rectangularmoldswerefilledwiththematerialsandpolymerizedinthesamemanner.

SampleEvaluation

ForCompressiveStrength

ThesamplesweretestedusingaUniversaltestingmachine(Fig. 3). The specimen was connected to a load measuring cell,which continuously recorded the load applied to the samples ata cross-head speed of 0.75 ± 0.25 mm/min until the specimenfractured.

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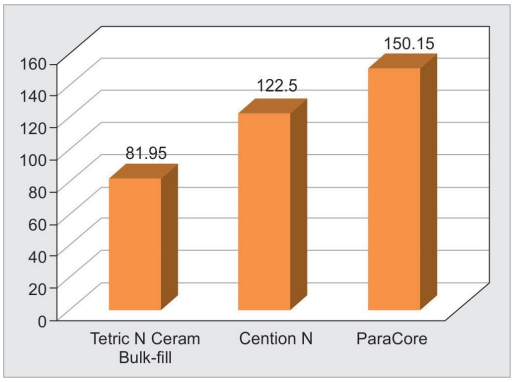

Fig.4: MeanFlexuralstrengthofParaCore,TetricNCeramBulk-fillandCentionN

Table1: ComparisonofmeanflexuralstrengthbetweenParaCore,TetricNCeramBulk-fillandCentionN

	N	*Mean*	*SD*	*p-value*
TetricNCeramBulk-fill	15	81.95	39.72	*p*=0.004**
CentionN	15	122.5	39.41	
ParaCore	15	150.15	72.82	

**Statistically significant at $p < 0.01$ using one way ANOVA. *N*, number; SD, standarddeviation

ForFlexuralStrength

The samples were tested using the three point bending test.The samples were connected to a load measuring cell, whichcontinuouslyrecordedtheloadappliedatthecenterofthesamples at a crosshead speed of 0.5 mm/min until the specimen fractured.Thedatawereobtainedandsubjectedtostatisticalanalysis.

StatisticalAnalysis

Statisticalanalysistocomparethemeancompressive(*N*=15foreachgroup)andflexuralstrength(*N*=15foreachgroup)ofcorematerials was performed. Data were analyzed using the statisticalpackage for social sciences (SPSS) version 11.5 (SPSS Inc, ChicagoIL). Mean values of compressive and flexural strength between thegroupswerecomparedusingone-wayANOVA(Analysisofvariance)andinter-groupcomparisonsweremadebasedon*post-hoc*valuesfromTukey'stestat5%levelofsignificance($p \leq 0.05$).

Results

The highest flexural strength was recorded for ParaCore™ followedbyCentionNandtheleastflexuralstrengthwasrecordedforTetricNCeramBulk-fillcomposite(Fig.4).Thedifferenceinmeanflexuralstrengthbetweenthethreecorebuild-upmaterialswasstatisticallysignificant ($p = 0.004$) (Table 1). A *post hoc* Tukey test revealed astatistically significant difference between Tetric N Ceram Bulk-fillcompositeandParaCore™(*p*=0.003)(Table2).

Thehighestcompressivestrengthwasrecordedfor ParaCore™ followed by Cention N and the lowest compressive strengthwas recorded for Tetric N Ceram Bulk-fill composites (Fig. 5).

Table2: Tukey*posthoc*testformultiplecomparisonofflexuralstrength

Dependentvariable	*MD*	*p-value*
TetricNCeramBulk-fill		
CentionN	–40.55	*p*=0.103(NS)
ParaCore	–68.19	*p*=0.003**
CentionN		
ParaCore	–27.6	*p*=0.336(NS)
TetricNCeramBulk-fill	40.55	*p*=0.103(NS)
ParaCore		
TetricNCeramBulk-fill	68.19	*p*=0.003**
CentionN	27.6	*p*=0.336(NS)

Thedifferenceinmeanflexuralstrengthbetweenthethreecore

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**Statistically significant using *post hoc* Tukeys test. MD, mean difference;NS,notsignificant

Fig.5: MeancompressivestrengthofParaCore,TetricNCeramBulk-fillandCentionN

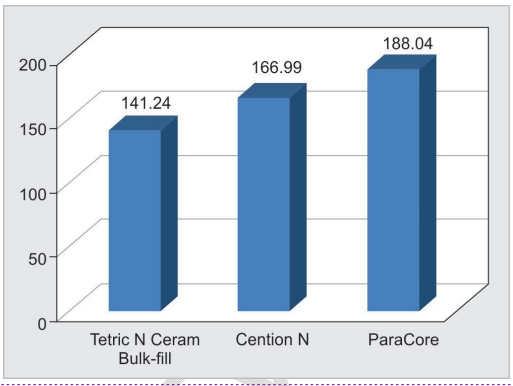

Table3: ComparisonofmeancompressivestrengthbetweenParaCore,TetricNCeramBulk-fillandCentionN

	N	*Mean*	*SD*	*p-value*
TetricNCeramBulk-fill	15	141.24	50.31	*p*=0.013*
CentionN	15	166.99	18.45	
ParaCore	15	188.04	47.27	

*Statisticallysignificantat*p*<0.05usingonewayANOVA.*N*,number;SD,standarddeviation

build-upmaterialswasstatisticallysignificant(*p*=0.013)(Table3).A *post hoc* Tukey test revealed a statistically significant differencebetweenTetricNCeramBulk-fillcompositeandParaCore™(*p*=0.001)(Table4).

DISCUSSION

The long-term success of post-endodontic restorations dependsmainlyontheadequacyofremaininghealthytoothstructureandthe effectiveness of the restorative materials used. Conservativeaccess openings, absence of clinical and radiographic featuresofbreakdown,enamelanddentinfracture,andboneresorption would contribute to a fair prognosis. However, scientific literaturehasrevealedthatendodonticallytreatedteetharemoresusceptibletofracturethanvitalteeth.[9,10]

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Table4: Tukey's *post hoc* test for multiple comparison of compressive strength

Dependent variable	*MD*	*p-value*
TetricNCeramBulk-fill		
CentionN	25.75	*p*=0.213(NS)
ParaCore™	46.8	*p*=0.001**
CentionN		
ParaCore™	21.05	*p*=0.344(NS)
TetricNCeramBulk-fill	–25.75	*p*=0.213(NS)
ParaCore™		
TetricNCeramBulk-fill	–46.8	*p*=0.001**
CentionN	–21.05	*p*=0.344(NS)

**Statistically significant using *post hoc* Tukey's test. MD, mean difference; NS, not significant

In the present study, among the three resin-based materials, ParaCore™ had the highest compressive and flexural strength when compared to TetricNCeramBulk-fill composites and CentionN. This finding is consistent with results from studies conducted by Sharma et al. and Majumder et al. where compressive and flexural strength was found to be highest in ParaCore™ core material when compared to other core build-up materials.[11,12] ParaCore™ is fiber-reinforced, dual-cured radiopaque core build-up material. Its improved physical properties can be attributed to its dual-cure nature that ensures complete cure in addition to its resin being reinforced with glass fibers. These fibers affect the fracture process resulting in interrupted crack growth progression thereby enhancing the fracture toughness of ParaCore™. Furthermore, the addition of Trimethylolpropane trimethacrylate (TMPTMA) acts as a cross linking agent with its polymeric matrices and improves its physical properties.[13] A study by Agarwal and Malaa lso reported similar findings with respect to its physical properties.[1]

In the present study, CentionN had more flexural strength than TetricNCeramBulk-fill composites but lesser than ParaCore™ core material. The findings were not consistent with the results from Chole et al. where CentionN had the highest flexural strength when compared to Bulk-fill composites, nanocomposites, and resin-modified Glass Ionomer cement (GIC).[14] Yet, in other studies, Hiremath et al. and Mishra et al. found that CentionN had higher flexural strength than Amalgam, resin-modified GIC, and lower flexural strength than nano-hybrid com[15,16] The compressive strength of CentionN in the present study was less than the compressive strength of ParaCore™. Nevertheless, Kaur et al. and Verma et al. reported a superior compressive strength for CentionN than GIC type IX with less microleakage compared to GIC and composite restorations demonstrating a better sealing ability as reported by Sujith et al.[17–19] The higher compressive strength of CentionN can be attributed to the higher filler content that is found in CentionN powder while liquid comprises of dimethacrylates and initiators. Urethane dimethacrylate (UDMA) is the main component that exhibits moderate viscosity and yields strong mechanical properties.

In addition to a better compressive and flexural strength, Cention N exhibits lower microleakage, prevents the recurrence of caries (due to long-term release of fluoride, calcium, and hydroxylions), has proximal contact tightness, has dual cure mechanism and possesses superior micro-hardness and fracture resistance properties.[20–24]

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The present study also found that Bulk-fill composites hadthe lowest flexural and compressive strength among the threematerialsusedinthepresentstudy.Hegdeetal.alsofoundreduced physicalpropertiesofBulk-fillcompositeswhencomparedtonewernanocomposites.[25] TetricCeramismicro-hybrid,light-curedcompositethatcontainsradiopaquefineparticlesoftenusedforrestorative therapy. Kim et al. attributed the reduction in physicalproperties to fibrous structures of microfill fillers that limit pastefillerloadingsresultinginpoorhandlingandsubsequentreduction in mechanical properties.[26] In addition, Mitra et al. reported thatdue to the small primary particle size, microfills retain the glossyappearance but produce poor bonds between the filler particleandresinmatrixthatlowersmechanicalproperties.[27]

The limitations of the present study were that it did not mimicthe clinical scenario and other physical properties of Cention Nmaterial could not be evaluated. The next leap of this study shouldbe to evaluate the long-term clinical success of these materialsunderfunctionalforces.

Conclusion

ParaCore™ had the highest compressive and flexural strengthswhen compared with Cention N and Tetric® N-Ceram™ Bulk-fillcomposite. The compressive and flexural strengths of Cention Nwere less than ParaCore™ but higher than Tetric® N-Ceram™ Bulk-fillcorebuild-upmaterial.

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