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A Comparative Evaluation of Calcium Hydroxide, MineralTrioxide Aggregate, Biodentine and Platelet Rich Fibrin in DirectPulp Capping of Cariously Exposed Mature Permanent Teeth:An*in-vivo*study

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Abstract:
Aim*: To evaluate and compare the clinical and radiographic success of direct pulp capping (DPC) treatmentusing Calcium hydroxide ($Ca(OH)_2$), Mineral Trioxide Aggregate (MTA), Biodentine and Platelet Rich Fibrin(PRF) in cariously exposed mature permanent teeth and to quantify and compare the amount of reparativedentinalbridgeformedateachfollow-upvisits.*
Materials and Methods*: 68 patients with 72 teeth (4 patients with 2 teeth each) with symptoms indicative ofreversible pulpitis were randomly allocated to the four groups and DPC was performed on satisfying theinclusioncriteria.Thepatientswererecalledat1,3,6and12monthspost-operativelyforclinicalandradiological evaluation. Standardization of all IOPAR were done with Image J software(version 1.53,NationalInstitutesofHealth,USA)fortheassessmentofwidthof reparativedentinbridge formation.*
Results*: It was observed that Biodentine produced maximum dentin bridge thickness at all follow up visits whilePRFformeda thickerdentinalbridge than $Ca(OH)_2$ and MTA at6monthsevaluation.*($p \leq 0.05$)
Conclusion: *Biodentine can be considered as the material of choice for DPC procedure, however PRF can alsobeused,asitisfrompatient'sbloodandpossessesdefinite role in regenerationofpulpaltissue.*
KeyWords*:DPC,$Ca(OH)_2$,MTA,Biodentine,PRF,Reparativedentin*

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I. Introduction

Pulpal inflammation is usually limited to within 2 mm of the exposure site even in the presence ofcarious pulp exposure unless it is of long-standing duration, and healthy pulpal tissue might be found in theremainingpulphornor furtherawayinthepulpchamber.[1,2]

In Direct pulp capping (DPC) the definitive goal is to preserve the underlying pulp and sustain itsvitalitybyregenerationofreparativedentinatthematerialpulpcomplex,whichactsasa–biologicalseal‖to shieldtheunderlyingpulptissues,toraisethelifeexpectancyofthetooth,andtoimprovetheoveralloralhealth.

The pulp-dentinal defects are mended by the production of these hard tissue barrier by stimulationleading to differentiation of undifferentiated mesenchymal cells of the dental pulp. This results in the formationof odontoblast-like cells which are involved in the synthesis of the dentin bridge.[3]It is confined to the localizedirritated areaofthepulpcavitywall,whichbecomesapparentmicroscopicallyaboutonemonthfromthe inception of thestimulus. It is structurally and chemically different from the primary andsecondary dentin, being highly atubular,impervious to most irritants and acts as a protective barrier for the pulp dentin complex.Its formation is acontinuousbutrelativelyslowprocess,taking100 daysto formareparativedentinlayerof 0.12mmthick.[4]

A vast array of pulp capping materials have been studied and used over the past century to stimulatedentin bridge formation, protection, and preservation of the pulp from further insult and ultimately sustain thevitalityofthe tooth.

Since several decades, Calcium hydroxide ($Ca(OH)_2$) has been considered as the gold standard DPCmaterial. Although the material exhibits many advantageous properties, outcomes of DPC with $Ca(OH)_2$ in longterm studies have been inconsistent.[5-8]Also exhibits poor dimensional stability and gets usually absorbed overtime.[9]Hencecanno longer beregardedasthe preferred universalagentinDPCtherapy.

Mineral Trioxide Aggregate (MTA) contains hydraulic calcium silicate powder comprising variousoxidecompounds.[11]MTAexhibitssuperiormarginaladaptation,uniformandthickerdentinbridgeformation,

less inflammatory response and less necrosis of pulpal tissues.[10-12]MTA has disadvantages such as longer settingtime, tooth discolorations, difficulthandlingcharacteristicsandhighcost.[13-16]

Biodentine is a tricalcium silicate-based cement that also demonstrates superior bioactive propertiessuch as short setting time of 10 minutes, excellent marginal adaptability, and high push out bond strength.[17-20]Disadvantagesinclude poorradioopacityand lowerwashoutresistance.

Platelet Rich Fibrin (PRF) is asecond-generation platelet concentrate. It has favorable properties,which include osteogenic ability, simple preparation, and no added biological agents. It has strong natural fibrinmatrixthatenmeshesalmostalloftheplateletsandgrowthfactorsofthebloodharvestwhichaidinregenerationofde ntalpulpandmaintenanceofpulpvitality.[21-23]ButitsabilityinDPChasnotyetbeenevaluated. Also, the literature is in dearth regarding the comparison of $Ca(OH)_2$, MTA, Biodentine and PRF asDPCagentsonthe basisoftheir potentialtoformreparativedentin.

II. Materials andMethods

A total of 68 patients with 72 teeth (4 patients with 2 teeth each) with symptoms of reversible pulpitiswereselectedforthestudyfromtheOutpatients'sectionofDepartmentofConservativeDentistryandEndodontic softhe College.

They were clinically and radiologically evaluated after taking thorough medical and dental history.Those who fulfilled the following criteria were included in the study-- clinically the tooth with deep caries, noswelling, pus exudation, fistula or mobility and positive response to sensibility tests-Cold test (RoekoEndofrost;Coltene, Whaledent, Germany) and Electric Pulp test and radiologically revealing the radiolucency to 3/4th ormore of dentinal thickness having no involvement in furcation or periapical regions, internal or external rootresorption,or calcification.

Medically compromised patients, pregnant and lactating mothers, teeth with spontaneous pain/ nightpain,cannotbeisolatedwithrubber damwithabnormalmobilityand lackofrestorabilitywereexcluded.

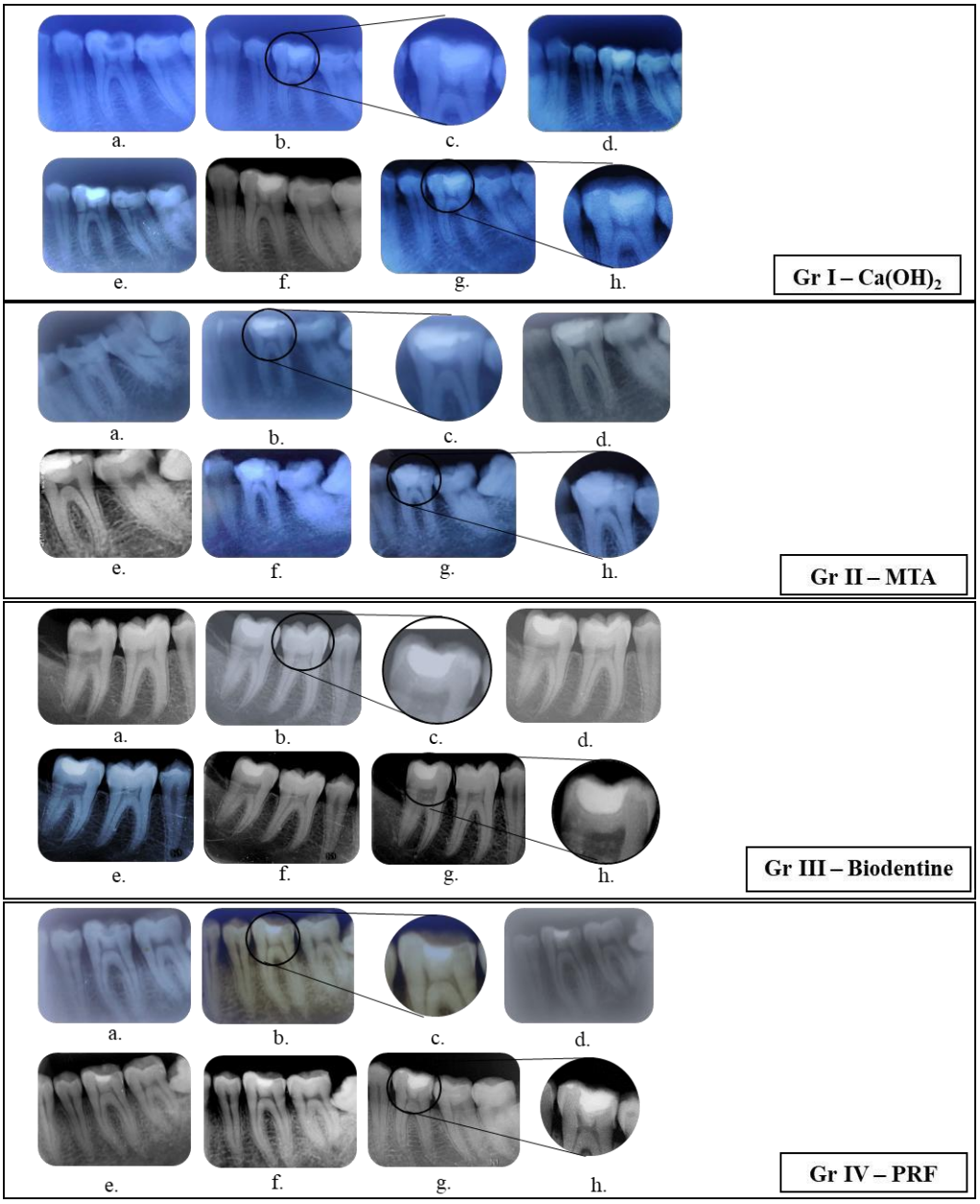
Written informed consent from the patients, and clearance from the institutional ethics committee wereobtained.

The teeth were anesthetized (2 % lignocaine with adrenaline 1:100000) and rubber dam isolation wasachieved. Caries excavation was performed initially with a sterile high speed round diamond bur, then onapproaching the pulp a sterile low-speed carbide round bur no.4 was used. On evident pulp exposure, the cavityfloor was irrigated with normal saline and the pulpal bleeding was ceased after gentle pressure application usinga pledget of cotton soaked in 3% Sodium hypochlorite (Prime Dental, India). Only the cases with pulp exposureupto approximately 2.5 mm and control of bleeding within 10 minutes were included. Once the hemorrhage wascontrolled, DPC was performed and the patients were then randomly allocated to the four study groups- Gr **I**-$Ca(OH)_2$,Gr**II**-MTA,Gr**III**-BiodentineandGr**IV**-PRF.

The materials in Gr **I, II** and **III** were mixed according to the manufacturer's instructions while PRFwas prepared from patient's blood according to Choukron's protocol[24] (2110 rpm for 10 minutes, 400G in acentrifugation machine- Remi R-8C centrifuge, India). The centrifuge thus formed had a PRF layer sandwichedbetween Platelet Poor Plasma (PPP) on top and RBC layer below. PRF was separated from the resultantcentrifuge using a sterile tweezer and was gently compressed using a sterile gauze and it was cut into smallerpieces and placed over the exposure site.The cavity floor and the dentinal walls were lined with RMGIC (GCFuji II LC) .Remaining cavity was restored with composite resin restoration (Te-Econom Plus composite,IvoclarVivadent,Liechtenstein)

Immediate post operative IOPAR was recorded. The patients were recalled at 1, 3, 6 and 12 months toevaluate pulp response to capping materials clinically as well as radiologically using IOPAR on the basis of rateofreparativedentinformation.StandardizationofallIOPARweredonewithImageJsoftware(version1.53,National Institute of Health,USA) for the assessment of width of dentin bridge formation. (IOPAR ofRepresentative Cases). The data of the patients who responded to the recall visits were subjected to statisticalanalysis.

IOPAROFREPRESENTATIVECASES



a.*Pre-op****b.****Immediatepost-op* ***c.****Magnified viewof* ***b.***

d.*1mon.post-op* ***e.****3 monpost-op* ***f.****6 mon post-op* ***g.****12monpost-op*

h.*Magnified view of****g.***

III. Result

Statistical Analysis- The collected data was tabulated in a spreadsheet using Microsoft Excel 2019 and thenstatistical analysis was carried out using IBM SPSS Statistics for Windows, Version 26.0. (Armonk, NY: IBMCorp). Box plots were constructed using the GraphPad Prism for Windows, Version 9.0 (GraphPad Software,LaJollaCaliforniaUSA).Friedman'sANOVAtestemployedtocomparethemeanrankswithintheobservations forthefourgroupsindividuallyandtheKruskal-WallisTestwascarriedouttocomparethemean ranks between the four groups for quantifying the thickness of the dentin bridge formed. An alpha level of 5%wasconsideredasthe level of statistical significance(*P≤0.05*).

Intra group comparisons (**Chart No.1,2,3,4 and Table 1**) showed, there was very strong evidence that thicknessof the dentin bridge formed was significantly higher at 12 months when compared to 3 months in all 4 studygroups,Gr**I**--*P*<0.001(Fig.1a),Gr**II**--*P*=0.001(Fig.1b),Gr**III**--*P*<0.001(Fig.1c)andGr**IV**—*P*=0.001(Fig.1d).

Inter group comparisons (Table 2), showed at 3 months (Fig. 2a)- there was strong evidence that thickness ofthe dentin bridge formed was significantly higher in the Biodentine group when compared to the $Ca(OH)_2$ group(*P*=0.05).

At 6 months (Fig. 2b)- thickness of the dentin bridge was significantly higher in the Biodentine group whencomparedtothe$Ca(OH)_2$group(*P*<0.001)andalsointhePRFgroupwhencomparedtothe$Ca(OH)_2$group(*P*=0.05).

At 12months (Fig. 2c)- thickness of dentin bridge formedwas significantly higher in the Biodentine groupwhen compared to the $Ca(OH)_2$ group (*P*<0.001) and also in Biodentine group when compared to the PRFgroup(*P*=0.01).

Chart No.1: FindingsofpatientsinGrI:$Ca(OH)_2$

GROUPI:$Ca(OH)_2$							
TOOTH SL.NO	**TOOTH NO**	**AGE/SEX**	**LAST FOLLOW UP(M)**	**SIZE OFEXPOSURE (mm)**	**DENTINBRIDGETHICKNESS(mm)**		
					3months	**6months**	**12months**
1	46	35/M	3	1.5	0.112		
2	37	27/M	3	1.5	0.143		
3	33	48/M	1	2	FAILUREAT1 MONTH		
4	46	62/M	1	2	FAILUREAT1 MONTH		
5	46	14/M	12	1.5	0.141	0.214	0.609
6	46	35/M	12	2	0.073	0.341	0.740
7	36	40/F	12	1.5	0	0.320	0.879
8	46	32/M	1	1	FAILUREAT1 MONTH		
9	35	25/F	12	1.5	0.052	0.404	1.016
10	35	36/F	12	2.5	0.142	0.620	1.103
11	46	19/M	12	0.5	0.133	0.340	0.851
12	36	23/F	12	2.5	0.161	0.602	0.842
13	15	33/M	12	1	0.145	0.297	0.793
14	37	22/F	12	2	0	0.294	1.021
15	12	45/F	12	1.5	0	0.440	1.040
MEDIAN					**0.12**	**0.34**	**0.87**
IQR					**0.013-0.14**	**0.3-0.48**	**0.78-1**
DENTINBRIDGE–80%(12/15cases)							

Chart No.2: FindingsofpatientsinGr II:MTA

GROUP II:MTA							
TOOTH SL.NO	**TOOTH NO**	**AGE/SEX**	**LAST FOLLOW UP(M)**	**SIZE OFEXPOSURE (mm)**	**DENTINBRIDGETHICKNESS(mm)**		
					3months	**6months**	**12months**
1	25	36/M	12	1.5	0	0.455	1.226
2	12	56/F	1	1.5	FAILUREAT1 MONTH		
3	36	34/M	12	1.5	0.268	0.461	1.102
4	36	29/M	12	2	0.429	0.658	1.035
5	36	26/M	12	2	0	0.477	1.075
6	37		12	2.5	0.188	0.581	1.007
7	36	27/F	12	2	0.358	0.607	1.228
8	26	28/M	12	0.5			0.953
9	11	20/F	12	2	0.295	0.934	1.412
10	35	35/F	1	1	FAILUREAT1 MONTH		
11	46	44/F	6	1	0.357	0.648	
MEDIAN					**0.28**	**0.59**	**1.1**
IQR					**0.047-0.36**	**0.47-0.66**	**1-1.2**
DENTINBRIDGE–81.82%(9/11cases)							

Chart No.3: FindingsofpatientsinGr III:Biodentine

GROUPIII:BIODENTINE							
TOOTH SL.NO	**TOOTH NO**	**AGE/SEX**	**LASTFOLLOWUP (M)**	**SIZE OFEXPOSURE (mm)**	**DENTINBRIDGETHICKNESS(mm)**		
					3months	**6months**	**12months**
1	11	24/M	12	1.5	0	0.740	1.377
2	46	38/M	12	1.5	0.599	0.778	1.138
3	47	24/M	12	2	0.374	0.689	1.120
4	46	22/F	12	1.5	0.295	0.890	1.100
5	34	40/M	12	1.5	0.340	0.950	1.280
6	44	28/F	12	2	0.168	1.104	1.940
7	46	20/M	12	2.5	0	1.030	1.820
8	25	28/F	1	2.5	FAILUREAT1 MONTH		
9	46	16/F	12	0.5	0.468	0.788	1.218
10	25	40/F	12	2.5	0.376	0.891	1.260
11	46	22/F	12	1	0	0.835	1.400
12	21	24/M	12	0.5	0.287	0.876	1.160
MEDIAN					**0.3**	**0.88**	**1.3**
IQR					**0-0.38**	**0.78-0.95**	**1.1-1.4**
DENTINBRIDGE–91.67%(11/12cases)							

Chart No.4: FindingsofpatientsinGr IV:PRF

GROUPIV:PRF							
TOOTH SL.NO	**TOOTH NO**	**AGE/SEX**	**LASTFOLLOWUP (M)**	**SIZE OFEXPOSURE (mm)**	**DENTINBRIDGETHICKNESS(mm)**		
					3months	**6months**	**12months**
1	46	24/M	12	1.5	0.220	0.781	0.990
2	36	38/M	12	1.5	0.242	0.840	0.913
3	36	19/M	12	2	0.440	0.730	0.980
4	46	22/F	12	1.5	0.244	0.814	1.056
5	36	20/M	1	2	FAILUREAT1 MONTH		
6	35	36/F	12	2.5	0	0.507	1.062
7	37	20/M	12	2	0.164	0.639	0.970
8	46	28/F	12	2.5	0	0.348	0.869
9	36	24/M	6	2.5		0.510	
10	36	16/F	3	2.5	FAILUREAT3MONTHS		
11	46	18/F	6	2.5	0.194	0.870	
12	46	23/M	1	2.5	FAILUREAT1 MONTH		
13	36	22/F	6	2		0.540	
14	36	27/M	6	0.5		0.568	
MEDIAN					**0.21**	**0.64**	**0.98**
IQR					**0.041-0.24**	**0.51-0.81**	**0.91-1.1**
DENTINBRIDGE–78.57%(11/14cases)							

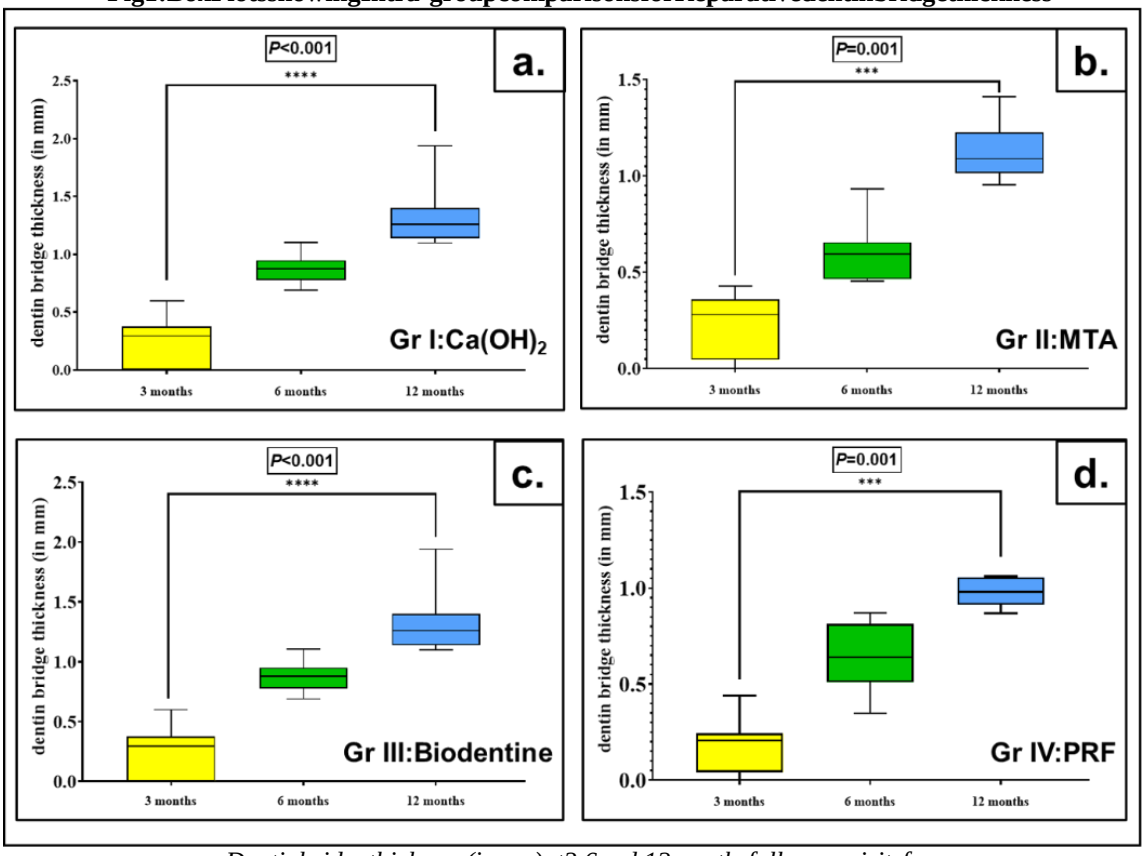
Table1:Comparisonoftheformeddentinbridgethicknessbetweendifferenttimeintervalsforeachgroup

Descriptivestatistics	**3months**	**6months**	**12months**	**Pairwisecomparison(months)**		
				Pvalue*		
				3 vs6	**3 vs12**	**6 vs12**
Group I:$Ca(OH)_2$	**(*n*=12)**	**(*n*=10)**	**(*n*=10)**			
Median	0.12	0.34	0.87	0.076	<0.001	0.076
IQR	0.013-0.14	0.3-0.48	0.78-1			
GroupII:MTA	**(*n*=8)**	**(*n*=8)**	**(*n*=8)**			
Median	0.28	0.59	1.1	0.184	0.001	0.184
IQR	0.047-0.36	0.47-0.66	1-1.2			
GroupIII:Biodentine	**(*n*=11)**	**(*n*=11)**	**(*n*=11)**			
Median	0.3	0.88	1.3	0.06	<0.001	0.06
IQR	0-0.38	0.78-0.95	1.1-1.4			
Group IV:PRF	**(*n*=9)**	**(*n*=11)**	**(*n*=7)**			
Median	0.21	0.64	0.98	0.184	0.001	0.184
IQR	0.041-0.24	0.51-0.81	0.91-1.1			

n=number of reported patients for respective monthMedianand IQRwascalculatedforallobservations

**Significancevalueshavebeen adjustedbytheBonferronicorrection formultipletests.*

Fig1:BoxPlotsshowingIntra-groupcomparisonsforReparativedentinbridgethickness



Dentinbridgethickness(inmm)at3,6and 12monthsfollowup visitsfor ***a.GrI- Ca(OH)$_2$b.GrII- MTAc. GrIII-Biodentine****and* ***d.GrIV- PRF***

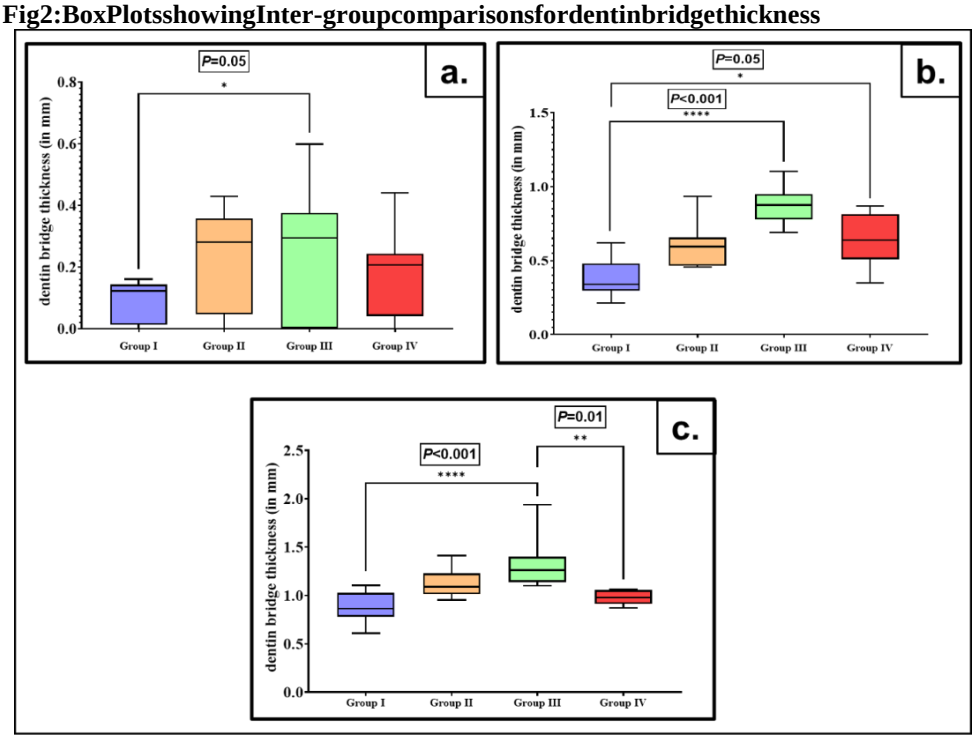
Table2:Comparisonoftheformed dentinbridgethicknessbetweenthestudygroups atdifferenttimeintervals

Descriptive statistics	Group I:Ca(OH)$_2$	Group II:MTA	Group III:Biodentine	Group IV:PRF	Pairwisecomparison(Groups) *Pvalue**					
					I vs II	I vsII	I vsIV	II vsIII	II vsIV	III vsIV
3Months	(*n*=12)	(*n*=8)	(*n*=11)	(*n*=9)						
Median	0.12	0.28	0.3	0.21	0.18	0.05	0.69	1.00	1.00	1.00
IQR	0.013-0.14	0.047-0.36	0-0.38	0.041-0.24						
6Months	(*n*=10)	(*n*=8)	(*n*=11)	(*n*=11)						
Median	0.34	0.59	0.88	0.64	0.25	<0.001	0.05	0.07	1.00	0.14
IQR	0.3-0.48	0.47-0.66	0.78-0.95	0.51-0.81						
12Months	(*n*=10)	(*n*=8)	(*n*=11)	(*n*=7)						
Median	0.87	1.1	1.3	0.98	0.08	<0.001	1.00	0.69	0.51	0.01
IQR	0.78-1	1-1.2	1.1-1.4	0.91-1.1						

n=number of reported patients for respective monthMedianand IQRwascalculatedforall observations

**Significancevalueshavebeen adjustedbytheBonferronicorrection formultipletests.*

Fig2:BoxPlotsshowingInter-groupcomparisonsfordentinbridgethickness



Comparisonofdentinbridgethickness(inmm)betweenGrI-Ca(OH)$_2$,GrII-MTA,GrIII-BiodentineandGrIV-PRFat ***a.3mon b. 6mon and c.12mon***

IV. Discussion

DPC is a vital pulp therapy technique which aims at maintaining pulpal tissueviability by protectingthepulpalsystemfrombacterialingressandhenceenhancingitsreparativecapacity.Thisinvolvestheplacement of a biocompatible agent on pulp tissue that has been exposed from carious process, traumatic injuryorbyiatrogenicmeans.Thesuccessofvitalpulptherapyrequiresabacterialtightseal,minimalornoinflammationa ndstable hemodynamicswithinthe pulp.

In the present study, only those patients were provisionally selected if they had deep caries almostinvolving the pulp with symptoms of reversible pulpitis, and responded positively to sensibility tests (Cold testand ElectricPulp test)andwithnoevidenceofswelling,pus exudation,fistula ormobility.

Pulpal exposure size of around 1 mm was considered for DPC treatment by some researchers. [25,26] Butin the present study, cases were selected for DPC with pulpal exposure around 2.5 mm in size. This wassupported by studies by Parinyaprom N *et al.* (2017) [27]&Bogen*et al.* (2008) [28].In the former study, the authorincluded subjects with pulpal exposure size upto 2.5mm and success rate of 92.6% to 96.4% was obtained usingMTA and Biodentine respectively. In the latter study, with the same exposure size, success rate of 98% wasobtained duringa9yearfollowupperiodwhenMTAwasusedfor DPC.

Another criteria which was followed was to include only those teeth in which pulpal hemorrhage couldbe controlled within 10 minutes of pulp exposure. This is supported by the fact that a diagnosis of reversiblepulpitis is best determined based on attaining hemostasis using NaOCl within 5-10 minutes of pulpal exposurerather than cold testing [Matsuo *et al.* (1996) [29]&Bogen*et al.* (2008) [28]]. A study done by Linu S *et al.* (2017)[30]supported thisandanoverallsuccessrate of88.5%wasobtained inthat study.

Literature supports the use of Ca(OH)$_2$ [31,32] ,MTA[28,33], Biodentine[34,35]as DPC agents. Two studies haveshown the use of PRF alone[36,37] as DPC agent and the latter study (author's own) reported with the formation ofreparative dentin with PRF.[37] Another study used PRF as pulp capping agent with Biodentine over it[38] anddesired successwasachieved.

In the present study Ca(OH)$_2$, MTA, Biodentine& PRF were used as individual DPC agents in 4differentgroupsofpatientstodetermine theirefficacy.

Due to Covid pandemic, out of the selected 68 patients, quite a good number of patients, could notattend the scheduled follow up visits and the result analysis was done with those patients who could attend therespective follow up visits. In 1st month follow up visit, patient came back with complaint of pain in 3 teeth inCa(OH)$_2$ group, 2 teeth in MTA group, 1 tooth in Biodentine group and 2 teeth in PRF group. In the latter groupsimilarfailurewasobservedin1toothin3monthsfollowupvisit,andwasconsideredasfailureandthereafter

no patient in any of the groups reported with any complaints indicating failure. Since radiologically detectabledentinal bridge was not observed after 1month, result analysis was not done. Therefore, DPC result analysiswasperformedat3,6and12monthsfollowupvisitsforpatientsofthefourGroupsandradiologicalobservationat 3monthswasconsidered asbaseline.

In the present study variations of age, gender and type of teeth were matched for the 4 groups ofpatients.It wasalsoseenthatsizeofpulpexposureand4groupsofsubjectscarriednosignificantassociation.

Detectabledentinbridgeformationwasobservedat3monthsonlyinthepresentstudy.Butahistological study done by Min *et al.* (2008)[39]found that 60% of teeth showed dentin bridge formation, with amean thickness of 0.131±0.01mm at 2 months. The thickness of radiologic dentinal bridge formed was higherwith passage of time and it was significantly high only at 12 months visit in all 4 groups compared to thebaselineat 3months.

When $Ca(OH)_2$ was used as DPC agent thickness of dentin bridge formed was seen in 80% of the cases(12/15) and was little more than 1 mm in few. And in majority it was less than 1 mm with median of 0.87 mm at12months.WhereasstudybyAgrawal*etal.*(2020)[38]reportedameanthicknessof1.15mm,1.24and 1.48mmat3 months, 6monthsand 12monthsrespectively.

The same dentin bridge formation was noted in 9 out of 11 subjects that is in 81.82% cases in MTAgroupand it was more than 1 mm in majority cases with median of 1.1 mm at 12 months. The findings of thepresent study were not in concordance with the findings of Aienehchi*et al.* (2003)[40],who hadreported athickness of 0.28 mm and 0.43 mm dentin bridge at 2 and 6 months, respectively. But, Agrawal *et al.*(2020)[38]reportedameanthicknessof1.25mm,1.45mmand1.72mmat3months,6monthsand12monthsrespectively.

In Biodentine group success was observed in 91.67% cases (11/12).These findings goes close to astudy by Abdul MS *et al.*(2021)[41] who reported 86.7% dentin bridge formation in the study subjects treated withBiodentine. Also, Muruganandhan*et al.* (2021)[42]reported dentin bridge formation in 100% of the teeth in whichDPC was performed using Biodentine, and was assessed by CBCT analysis.Agrawal*et al.*(2020)[38] reported amean thickness of 1.32 mm,1.54 mm and 1.74 mm at 3 months, 6 months and 12 months respectively. Whereasmedian thickness of 0.3mm,0.88mm and1.3mmwas observedin thesaidfollow upvisits in the presentstudy.

Reparative dentine formation in PRF groupwas noted in 78.57% ie. 11 out of 14 subjects. At 12months visit in majority cases it was around 1 mm with median of 0.98 mm. A study conducted by Agrawal *etal.* (2020)[38]reported a mean reparative dentinal thickness of 1.42 mm, 1.62 mm and 1.84 mm at 3 months, 6months and 12 months respectively. However, in that study, Biodentine was placed over the PRF membraneacting as an osteo-inductivematerial, thusexplaining theincreaseddentinalthicknessas compared to thepresentstudy.

At 3 months, the maximum thicknesswas found in the Biodentine group, followed by MTA, PRF and$Ca(OH)_2$ group in sequence of order.The thickness of the dentin bridge formed was significantly higher in theBiodentinegrouponlywhencomparedtothegoldstandard$Ca(OH)_2$ group.Otherwise,the difference inthicknesswere seencomparable toeachother.

On the other hand, in the study conducted by Agrawal *et al.*(2020)[38], the thickness of dentin bridgeformed at 3 months follow-up was found to be significantly highest in the PRF group, followed by Biodentine,MTA and Calcium hydroxide, but in that study, Biodentine was placed over the PRF membrane acting as anosteo-inductive material,thus producing a synergistic effect on the dentinal bridge thickness as compared to thepresent study. Also, $Ca(OH)_2$followed by MTA formed the least thickness of dentinal bridge in their study,which wasfoundinthe presentstudyalso.

At 6 months dentin bridge thickness differed significantly among the four groups. The maximumthicknesswas found in the Biodentine group, followed by PRF, MTA and $Ca(OH)_2$group.The thickness of thedentin bridge formed was significantly higher in the Biodentine group and PRF group when compared to the$Ca(OH)_2$ group, otherwise the difference in thickness were seen comparable to each other. The same study ofAgrawal *et al.* (2020)[38] also showed significantly higher dentin bridge thickness in 6 months follow up whenBiodentine&PRFused togetherorBiodentine used alone.

At 12 months dentin bridge thickness differed significantly among the four groups. The maximumthicknesswas found in the Biodentine group, followed by MTA, PRF and $Ca(OH)_2$group.The thickness of thedentin bridge formed was significantly higher in the Biodentine group when compared to both $Ca(OH)_2$ groupand PRF group, otherwise the difference in thickness were seen comparable to each other.On the other hand, inthe same study conducted by Agrawal *et al.*(2020)[38], on obvious reason the thickness of dentin bridge formed at12months follow-upwas foundto be significantly highest in the PRF &Biodentine combinedgroup incomparisontoothergroups.

Thus, it can be stated that the thickness of dentinal bridge which was formed in the Biodentine groupwassignificantlyhigherthan$Ca(OH)_2$groupatallfollow-upperiods;andalso,thanthePRFgroupat12

months.Theamountofdentinbridgeformedin thePRFgroupwascomparabletotheCa(OH)$_2$groupexceptat6 monthsfollow-up in whichthedentinal thicknesswassignificantlyhigher inthe PRFgroup.

V. Conclusion

Thus, within the constraints and limitations of the present study it can be concluded that:DPC agentsused in the study showed a significant increase in reparative dentinal bridge thickness at 12 months whencompared to that formed at 3 months. Maximum thickness of dentin bridge formation was shown by Biodentineat all follow up visits, thus cementing its value in DPC procedures. However, PRF formed a thicker dentinalbridge than Ca(OH)$_2$ and MTA at 6 months evaluation and hence can be used instead. It is from patient's bloodand possesses definite role in regeneration of pulpal tissue,though further studies with long term follow upsneed tobe conducted toconfirmitseffective use inDPCprocedures.

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