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The Effect of Time and Storage Environment on Dimensional Changes of Acrylic Resin Post Patterns

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Abstract: *Introduction*: Post and core are needed to regain retentions and functions after endodontic therapies. Also, risk of cross contamination from dental prosthesis is so high. The aim of this study was to compare dimensional changes of acrylic resin patterns (ARP) in three different storing environments. *Materials and methods*: conventional root canal therapy was done on one first premolar tooth and the canal filled with Guttapercha. 2/3 of the filling was expelled and 30 direct APRs were prepared by Duralay. The samples were divided into 3 groups based on storing environments: water, NaOCl 5% and air. Finally dimensional changes in coronoapical length (CAL), coronal (CD) and apical diameter (AD) of APRs were measured in 7 consecutive times (immediately after polymerization, 1, 2, 4, 8, 24, 48 hours later). All the data were analyzed by Paired T-test and Duncon test using SPSS software ver.13 at significant level of 0.05. *Results*: After 24 hours, the ARPs, which were stored in air, contracted 0.07, 0.06 and 0.12 mm in AD, CD and CAL; the ARPs, which were stored in water, showed 0.03, 0.06 and 0.12 mm decrease in AD, CD and CAL; But the ARPs, which were stored in NaOCl 5%, showed significant expansion in AD, CD and CAL (0.03, 0.06 and 0.10 mm) (all P values < 0.01). *Conclusion*: It is better not to use NaOCl for disinfecting; also the best time for storing APRs is 8 hours for water and 2 hours for air environments after setting time.

Keywords: Acrylic resins, apical diameter (AD), dimensional change, disinfection, NaOCl 5%, post and core.

INTRODUCTION

Contemporary dentistry relays on dental materials such as many types of polymers and plastics which have gain a special situation nowadays [1, 2]. Acrylic resins are one of the polymers which are used widely in dentistry [3, 4]. Reconstruction of tooth structures is one of the basic treatment plans after endodontic therapies in modern dentistry. Posts and cores are needed to regain retention and function [5, 6]. Direct acrylic resin patterns (ARP) of the canal with precision and stable dimensions are required for casting post and core [7- 9]. These ARPs, like other resins, have shrinkages due to the polymerization procedure and might have an impact on retention and resistance of final posts and cores [6, 7, 9].

Wide or short interface between canal and post (caused by ARPs without precision) would fill with too thick or thin layers of cement which are infirm to long term forces and might lead to fracture and failure of post and core [10-13]. Eames *et al.* conducted a study about techniques to improve seating of the castings. They observed 10 to 30 micrometers interface, which was caused by shrinkage of ARPs [14].

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J Ghanbarzadeh compared the effect of storage time and conditions on dimensional stability of ARPs. He claimed that storing time significantly affected only post diameter (not post length or core diameter) [15]. A. Taiefe Davaloo *et al.* [5] claimed that dry condition was better than humid condition in contrast with another study [16] in which the opposite conclusion was reported.

Dental laboratory staffs are at risk of cross contamination from not disinfected dental prosthesis. So using some disinfectants like Sodium Hypochloride (NaOCl) and Glutaraldehyde might affect the precision of ARPs [4, 17-22]. Mahshid *et al.* studied the effects of time elapse, disinfection solutions and storage environments on dimension stabilities of Duralay ARP. They concluded that there were no differences between wet and dry conditions; also Glutaraldehyde caused contraction and NOCl made expansion of ARP. However, the mechanism of this different impact was not understood [18]. In another study, Nirale *et al.* observed the effect of NaOCl and microwave disinfectants on dimensional changes of denture bases and concluded that NaOCl did not make any significant dimensional changes [19].

Because disinfecting is an inevitable procedure which avoids cross contamination, determining the best condition or disinfection for storing ARPs without any dimensional changes is so important. As condition of storing ARP for

direct post and core fabrication is somehow controversial [16, 18, 19], and previous studies did not make so much effort to evaluate the effects of NaOCl on ARPs carefully, the aim of present study was to compare dimensional changes of Duralay ARPs in environments of air, water and NaOCl as a disinfectant.

The null hypothesis is that water and NaOCl would not make any significant differences in dimensions of Duralay ARPs especially after 24 hours.

MATERIALS AND METHODS

In this observational-analytical *in vitro* study, standard root canal therapy was done on one first mandibular premolar tooth in order to prepare 30 ARPs. In the first stage, straight line access was made by using high speed fissure burs (Teeskavan, Tehran, Iran) and rotary instruments (FKG Dentaire, La Chaux-de- Fonds, Switzerland). Step-back technique was administered for endodontic treatment. After cleaning and shaping by K-files (Dentsply Maillefer, Ballaigues, Switzerland) up to a size # 80, lateral condensation technique was done to fill the canal with Guttapercha (Diadent Group International Inc., Vancouver, Canada) and final periapical radiography was taken (Fig. **1A**). One week later, the crown was sectioned horizontally from the top of the orifice by a double-sided diamond disc (Teeskavan, Tehran, Iran) and using a low-speed straight handpiece (Kavo, Joinville, SC, Brazil) in order to prepare ARPs easier and similar to clinical conditions (In many cases the crowns are fractured due to trauma or some parts of the crowns would be milled for preparing post and cores). The external margins of the tooth were beveled. 2/3 Guttapercha filing was expelled and inner rim of the canal was shaped by Peso reamer (Largo peso reamer, Dentsply Maillefer, Ballaigues, Switzerland) and Gates-glidden drills (Dentsply Maillefer, Ballaigues, Switzerland). One periapical radiograph was taken to evaluate the prepared canal and the apical seal (Fig. **1B**).

Before making patterns, Vaseline was used to lubricate the canal, then Duralay acrylic resin (Reliance Dental Mfg. Co., Alsip, USA) was manipulated based on manufacturer instruction. Loose consistency of acryl was driven to the canal by using a plastic sprue (Pinjet, Angelus, Londoria, Brazil) to fabricate direct ARP of the canal (Fig. **1C**). Also, a thin layer of loose acryl (Reliance Dental Mfg. Co) was added to the canal to make precise and complete ARP. In the final stage of acrylic polymerization, the excessive acryl was removed to define the coronal border of the post. The plastic sprue (Pinjet, Angelus) remained inside and the ARP was removed from the canal after 7 minutes (final setting time). Then immediate measurement was done to have a reference point and it was assumed as basic measurement. This ARP, which had no shrinkages, would be so close to real dimensions of the canal. So, corono-apical length (CAL), coronal (CD) and apical diameters (AD) were measured immediately. The distance from apical point to coronal margin was considered as CAL; AD was defined as the mesiodistal distance from 1.5 mm above the apical point and CD was defined as the mesiodistal distance from 1.5 mm beyond the coronal margin of ARP.

The 30 fabricated ARPs were stored into following storage environments: water, NaOCl 5% (Golrang, Pakshoo Co. Tehran, Iran) and air (Fig. **1D**) in 25°C temperature. The CAL, AD and CD of the ARPs were measured in 6 other consecutive times (1, 2, 4, 8, 24, 48 hours later) by using a digital micrometer (Mitutoyo, Illinois, USA). The collected data from these mentioned intervals (6 consecutive times) were compared with the base measurements and analyzed by Paired T-test and Duncan using SPSS software version 13 at significant level of 0.05.

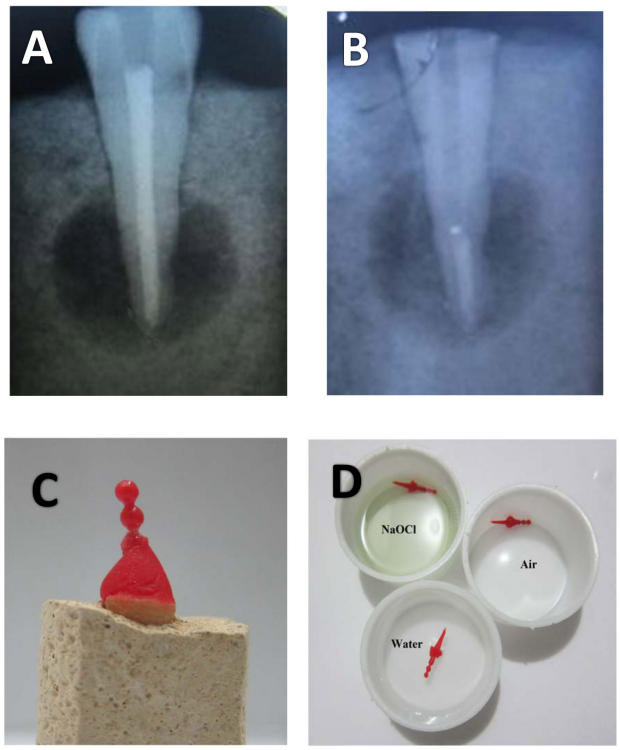

Fig. (1). Periapical radiography of the first mandibular premolar after endodontic therapy (**A**); periapical radiography of the tooth after sectioning and preparing for ARP (**B**); preparing Duralay ARP by using plastic sprue (**C**); storing ARPs in different environments (**D**).

RESULTS

Table **1** represents the means and standard deviations of measured CAL, AD and CD in three different environments.

The data showed the ARPs, which were stored in air, contracted 0.02, 0.01 and 0.01 mm in AD, CD and CAL after 1 hour. The shrinkage continued but in lesser rates. Contraction was observed after 24 hours in AD, CD and CAL (0.07, 0.06 and 0.12 mm).

The ARPs, which were stored in water, showed 0.01 mm contractions in AD, CD and CAL after 1 hour. Also 0.03, 0.06 and 0.12 mm decrease was seen in AD, CD and CAL after 24 hours.

But the ARPs, which were stored in NaOCl 5%, showed significant expansion in size. AD, CD and CAL expanded 0.08, 0.01 and 0.08 mm after 1 hour. The CD showed the least expansion. Also, the expansion continued in AD, CD and CAL (0.03, 0.06 and 0.10 mm) after 24 hours.

Table 1. Dimensional changes (mm) and P values of ARPs in different environments.

Environment	Time	Apical		Coronal		Corono-apical	
		Diameter	*P value*	*Diameter*	*P value*	*Diameter*	*P value*
Air	Basic	1.62 ± 0.16	-	2.22 ± 0.17	-	11.26 ± 0.54	-
	1	1.60 ± 0.17	<0.001	2.21 ± 0.18	0.009	11.25 ± 0.53	0.003
	2	1.58 ± 0.16	<0.001	2.20 ± 0.22	0.004	11.23 ± 0.49	<0.001
	4	1.56 ± 0.15	<0.001	2.18 ± 0.22	<0.001	11.17 ± 0.56	0.007
	8	1.56 ± 0.16	<0.001	2.16 ± 0.23	<0.001	11.15 ± 0.53	0.025
	24	1.55 ± 0.15	<0.001	2.16 ± 0.23	<0.001	11.14 ± 0.53	0.019
	48	1.55 ± 0.15	<0.001	2.15 ± 0.23	<0.001	11.14 ± 0.53	0.019
NaOCl	Basic	1.42 ± 0.12	-	1.99 ± 0.11	-	10.92 ± 0.93	-
	1	1.50 ± 0.10	<0.001	2.00 ± 0.16	0.12	11.00 ± 0.91	0.020
	2	1.54 ± 0.12	<0.001	2.00 ± 0.15	0.007	11.08 ± 0.91	0.042
	4	1.60 ± 0.11	<0.001	2.06 ± 0.14	<0.001	11.12 ± 0.91	0.016
	8	1.66 ± 0.09	<0.001	2.13 ± 0.13	<0.001	11.15 ± 0.90	0.012
	24	1.68 ± 0.09	<0.001	2.14 ± 0.13	<0.001	11.16 ± 0.90	0.010
	48	1.68 ± 0.09	<0.001	2.15 ± 0.13	<0.001	11.16 ± 0.89	0.006
Water	Basic	1.43 ± 0.11	-	1.93 ± 0.23	-	12.50 ± 1.22	-
	1	1.42 ± 0.13	0.018	1.92 ± 0.24	0.010	12.49 ± 1.21	0.01
	2	1.41 ± 0.13	<0.001	1.91 ± 0.24	<0.001	12.48 ± 1.22	0.002
	4	1.40 ± 0.13	<0.001	1.89 ± 0.24	<0.001	12.43 ± 1.20	<0.001
	8	1.40 ± 0.16	<0.001	1.87 ± 0.24	<0.001	12.41 ± 1.19	<0.001
	24	1.40 ± 0.16	<0.001	1.87 ± 0.24	<0.001	12.40 ± 1.19	<0.001
	48	1.39 ± 0.16	<0.001	1.86 ± 0.24	<0.001	12.40 ± 1.19	<0.001

Paired T-test analyze showed that ARPs contracted in water (P value < 0.01) and air (P value < 0.02) condition in contrast with NaOCl solution which made expansion in samples (P value < 0.05).

Duncan statistical test showed significant differences in CAL, AD and CD of the ARPs which were stored in 3 different environments (P value<0.025).

DISCUSSION

It has been shown that one of the main reasons of vertical root fracture is the insertion of cast posts and cores due to a wedging effect which is caused by cement hydraulic pressure. Therefore, precise fabrication of ARPs with acceptable and stable dimensions during investing, burning out and casting can significantly affect the reduction of further vertical fractures [7, 6, 9].

The analyzed results support rejecting the stated null hypothesis and significant difference was found in dimensions especially for NaOCl which caused expansions after 24 hours (P values < 0.01).

As the results show; the AD, CD and CAL of Duralay ARPs decreased in water and air conditions. The contraction was apparently lower in water than air conditions. In contrast, NaOCl solution made increase in sizes of samples and caused unstable condition of storing. Hence, the water prepares the best condition for storing Duralay ARPs, especially during first 8 hours.

Mahshid *et al.* claimed that the decrease was obvious in the length and diameter size of acrylic Duralay ARPs in air condition; however, expansions were observed in NOCl condition after 24 hours [18]. They prepared ARPs in 10 metal cylinders without any similarities to a normal tooth canal. However, plastic sprues surrounded by Duralay resin were used in present study to make ARPs more similar to shape and size of mandibular first premolar canal. The present results showed that the best time, to store samples in air, was until 2 hours after the final setting of the ARPs. In mentioned study, the initial time of measuring was 17 minutes after the samples sat while 80% of contraction proceeded until then [12]. These mentioned differences might be the reason of different recorded data between two studies.

J Ghanbarzadeh revealed that the best condition for storing Duralay ARPs was 100% humidity-same as present study- in 25°C after 24 hours. A metal cylinder was used to create ARPs and storage conditions were air, water and refrigerator [15]; but in present study NaOCl was used instead of refrigerator. In that study changes were recorded in 3 times (0, 24 and 48 hour later), however, present study tried out to make it more precise by measuring 7 time intervals.

Timing and intervals are important factors in recorded final results.

Cahi E *el al.* made observation on dimensional stability of three different inlay pattern materials which were measured in every one hour intervals. They concluded that more contraction occurred at 24 hours [16]. This study admitted that results, but difference is that present study was attempted to observe changes in different environments. A brass master model was used in that study but a premolar tooth was used in present study to make observation more actual.

In another study by A. Taiefe Davaloo *et al.*; Duralay ARPs were stored in air and water for one week. After measuring, they concluded that it was better to store ARPs in air condition because the water makes expansion after one week [5]. Respectfully, it is obvious that as the time lasts the acrylic resins absorb more water and expand more and more [4], so 7 time intervals were scheduled with short durations in present study.

CONCLUSION

With the limitation of this study (like using one disinfection solution, sample size and using one type of resins), it is better not to use NaOCl for disinfecting but recommending other disinfections needs more observations. The best environment to store Duralay ARPs was water especially in the first 8 hours. Also present results showed that the best time to store samples in exposure of air was until 2 hours after samples were sat in which they have the least shrinkages. It's recommended to store Duralay ARPs in water until laboratory casting. Finally, it is suggested to explore more disinfections and resins type, also it might be useful to investigate the dimensional changes after casting of the ARPs in further studies.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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