A Study To Evaluate The Effect Of Sterilization And Disinfection On Tensile Strength Of Orthodontic Elastomers

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ABSTRACT

Introduction: Sterilization refers to a process that eliminates all living organisms, including both pathogenic and non-pathogenic entities, in their vegetative state or as spores found the exterior of the material intended for sterilization. Throughout the years, the predominant methods of physical heat sterilization utilized practices in dentistry have included saturated steam, dry heat and chemical vapour. The processes of sterilization and disinfections are fundamental elements of any infection control program within a healthcare environment. Although elastomeric chains and intraoral elastics are widely accepted and utilized, there remains a degree of uncertainty regarding their mechanical and biological characteristics following sterilization and disinfection procedures.
Material and methods: A sample of 60 orthodontic elastomers were collected. These samples were further divided into two groups, as elastomeric chain and intraoral elastics. Each group will be further subdivided into 6 sub-groups depending upon the different sterilization and disinfectant methods - Control Group; 2% Glutaraldehyde; 70% Alcohol; 1% Peracetic acid; Hot Water (70°); and Autoclave. The samples were tested for evaluation of tensile strength in a Universal Testing Machine. The data collected underwent statistical analysis.
Results:The study showed that in Elastomeric Chain group, there was a statistically meaningful difference in Control Group versus 1% Peracetic Acid and Autoclave with respect to tensile strength. In Intraoral Elastics group, there was a statistically meaningful difference in tensile strength between the control group versus 2% glutaraldehyde, 1% peracetic acid and hot water.
Conclusion:The statistically significant differences observed in study regarding the disinfection and sterilization of orthodontic elastomers lead us to conclude that alcohol, 2% glutaraldehyde and hot water were suitable for the sterilization of Elastomeric Chains, while alcohol and autoclaving were appropriate for Intraoral Elastics.

Keywords: Elastomeric Chain; Intraoral elastics; Sterilization; Disinfection; Orthodontic elastomers.

Introduction

Sterilization is a process that eliminates all living organisms, both pathogenic and non-pathogenic, in their vegetative state or as spores found on the surfaces of materials designated for sterilization[7]. Disinfectants are chemical formulations specifically created to eliminate a wide variety of microbial organisms, encompassing the majority of bacteria, viruses and parasites[13].
The objective of infection control within dental practice is to avert the spread of pathogenic agents, including bacteria, viruses and fungi, between patients, as well as from dental practitioners and staff to patients and vice versa[15].Despite significant advancements in orthodontics, including the development of innovative materials and techniques, the adherence of microorganisms to these materials during orthodontic procedures continues to be a matter of concern. While dental instruments undergo sterilization prior to use, orthodontic components such as brackets, bands, archwires, elastomeric ligatures and chains are utilized in their original state as provided by manufacturers for clinical applications[1].
Infection control protocols encompass the cleaning and sterilization processes for reusable dental instruments and devices. The practices of sterilization and disinfection are the essential components of any

infection control programme during a healthcare setting[9].

During orthodontic treatment, individuals may face an increased likelihood of experiencing periodontal complications, notably periodontal disease[6].

The microorganisms that accumulate around the brackets of a fixed orthodontic appliance can enter the patient's bloodstream after procedures in which the oral tissues are manipulated and cause transient bacteremia[10].

Elastomer refers to a broad category of material that can undergo notable alterations in deformation and subsequently revert quickly to their initial shape[8]. The primary benefits of elastomers include their ease of handling, the lack of necessity for patient cooperation and their comfort, hygiene and cost-effectiveness[14].

Although elastomeric chains are widely accepted and utilized, there remains a degree of uncertainty regarding their mechanical and biological properties following sterilization and disinfection processes. Elastomeric chains and elastics, being unstructured polymers composed of polyurethane, exhibit properties that are a blend of rubber and plastic. Consequently, their distinctive properties can be modified when subjected to physical stimuli or chemical agents[11]. Thus, the current study was designed to assess the most efficient method to sterilize and disinfect elastomeric chains and elastics without compromising their mechanical properties.

Material and methods

A sample of 60 orthodontic elastomers were collected. These samples were further divided into two groups, as elastomeric chain (G&H Orthodontics)(Figure 1) and intraoral elastics (TP Orthodontics) (Figure 2). Each group will be further subdivided into 6 sub-groups depending upon the different sterilization and disinfectant methods - Control Group; 2% Glutaraldehyde; 70% Alcohol; 1% Peracetic acid; Hot Water (70°); and Autoclave (Table 1).

Groups	Sub-Groups	Method of sterilization & disinfection	Time of sterilization & disinfection	No. of Samples (n)
Elastomeric Chain (Group A)	Sub-Group A1	Control	Not immersed in any solution	5
	Sub-Group A2	2% Glutaraldehyde	30 minutes	5
	Sub-Group A3	70% Alcohol	30 minutes	5
	Sub-Group A4	1% Peracetic acid	30 minutes	5
	Sub-Group A5	Hot Water (70°C)	30 seconds	5
	Sub-Group A6	Autoclave	121°C at 15 psi for 15 minutes	5
Intraoral Elastics (Group B)	Sub-Group B1	Control	Not immersed in any solution	5
	Sub-Group B2	2% Glutaraldehyde	30 minutes	5
	Sub-Group B3	70% Alcohol	30 minutes	5
	Sub-Group B4	1% Peracetic acid	30 minutes	5
	Sub-Group B5	Hot Water (70°C)	30 seconds	5
	Sub-Group B6	Autoclave	121°C at 15 psi for 15 minutes	5

TABLE 1: Different sterilization and disinfectant methods - Control Group; 2% Glutaraldehyde; 70% Alcohol; 1% Peracetic acid; Hot Water (70°); and Autoclave.

FIGURE 1: Short Clear Elastomeric Chain (G&H Orthodontics)

FIGURE 2: Intraoral Elastics(TP Orthodontics)

After the sterilization and disinfection methods, samples were washed with the distilled water for 5 mins to remove the remaining disinfectant residues and dried with absorbent paper. The washing and drying procedure was repeated again after 30 minutes for the complete removal of disinfectant residues. After the complete washing and drying procedure, the samples were kept into the closed test tube. All the samples were stored at the room temperature for 7 days. After 7 days, the samples were tested for tensile strength using Universal Testing Machine (UTM) (Figure 3). Two custom made jigs (Figure 4) were attached to the universal testing machine and elastomeric chain was stretched between the two jigs and the readings for the tensile strength were taken until fracture. The same procedure was repeated for the tensile strength of the intraoral elastics.

FIGURE 3:Universal Testing Machine

FIGURE 4:Custom Made Assemblies

Statistical analysis: The sterilization and disinfection treatment on tensile strength of the orthodontic elastomers was statistically analyzed using descriptive analysis and ANOVA test. Further, a Dunnett ‘t’ (2-sided) test was done to compare the control group to the each other groups using the data. All statistical analysis were performed at $P<0.05$ level of significance.

Results

The study was conducted with a total sample size of 60. These samples were divided into two groups: Group A: Elastomeric chain; and Group B: Intraoral Elastics. These groups were further divided into 6 sub-groups depending upon the different sterilization and disinfectant methods. These subgroups were control group; 2% Glutaraldehyde; 70% Alcohol; 1% Peracetic Acid; Hot water and Autoclave.

Descriptive statistical analysis including Mean and Standard Deviation were calculated for each of the test groups. **Table 2** depicts the mean values of tensile strength and elongation of all test groups for Group A: Elastomeric chain. **Table 3** depicts the mean values of tensile strength and elongation of all test groups for Group B: Intraoral Elastics.

DESCRIPTIVE									
ELASTOMERIC CHAIN		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
TENSLE STRENGTH	Group A1 (Control)	5	17.4000	1.66883	.74632	15.3279	19.4721	15.10	19.00
	Group A2 (2% Glutaraldehyde)	5	20.4800	3.27368	1.46404	16.4152	24.5448	15.60	23.90
	Group A3 (70% alcohol)	5	17.4600	.48270	.21587	16.8606	18.0594	16.80	18.10
	Group A4 (1% peracetic acid)	5	21.5200	2.62621	1.17448	18.2591	24.7809	18.40	23.50
	Group A5 (Hot water)	5	19.6600	2.44704	1.09435	16.6216	22.6984	15.30	21.00
	Group A6 (Autoclave)	5	25.4800	1.28335	.57393	23.8865	27.0735	23.30	26.60
	Total	**30**	**20.3333**	**3.42016**	**.62443**	**19.0562**	**21.6104**	**15.10**	**26.60**
ELONGATION	Group A1 (Control)	5	636.4000	31.48492	14.08048	597.3063	675.4937	589.00	672.00
	Group A2 (2% Glutaraldehyde)	5	696.9600	20.37408	9.11156	671.6622	722.2578	666.20	720.00
	Group A3 (70% alcohol)	5	743.9000	48.83943	21.84166	683.2578	804.5422	657.20	773.00
	Group A4 (1% peracetic acid)	5	721.6740	41.82821	18.70614	669.7374	773.6106	660.87	754.20
	Group A5 (Hot water)	5	702.6240	32.49684	14.53303	662.2738	742.9742	645.21	724.50
	Group A6 (Autoclave)	5	847.3020	15.13372	6.76800	828.5110	866.0930	824.50	863.12
	Total	**30**	**724.8100**	**71.82812**	**13.11396**	**697.9889**	**751.6311**	**589.00**	**863.12**

TABLE 2: Comparison of mean value and standard deviation of Tensile Strength (Newton) & Elongation (percentage) of Elastomeric chain

DESCRIPTIVE									
INTRAORAL ELASTICS		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
TENSILE STRENGH	Group B1 (Control)	5	21.8200	1.42373	0.63671	20.0522	23.5878	19.70	23.50
	Group B2 (2% Glutaraldehyde)	5	29.2600	2.44602	1.09389	26.2229	32.2971	25.90	32.10
	Group B3 (70% alcohol)	5	26.6600	3.68755	1.64912	22.0813	31.2387	21.80	31.20
	Group B4 (1% peracetic acid)	5	27.3200	4.79448	2.14415	21.3669	33.2731	19.80	31.90

	Group B5 (Hot water)	5	27.4800	3.35664	1.50113	23.3122	31.6478	23.80	32.20
	Group B6 (Autoclave)	5	26.9000	2.47184	1.10544	23.8308	29.9692	24.20	29.70
	Total	**30**	**26.5733**	**3.73436**	**.68180**	**25.1789**	**27.9678**	**19.70**	**32.20**
ELONGATION	Group B1 (Control)	5	705.2600	26.15355	11.69622	672.7861	737.7339	662.50	731.50
	Group B2 (2% Glutaraldehyde)	5	753.2200	4.05535	1.81361	748.1846	758.2554	748.44	757.95
	Group B3 (70% alcohol)	5	716.0300	26.12888	11.68519	683.5867	748.4733	680.73	748.14
	Group B4 (1% peracetic acid)	5	742.1480	18.17018	8.12595	719.5867	764.7093	718.43	768.19
	Group B5 (Hot water)	5	721.7700	25.76008	11.52026	689.7846	753.7554	685.07	755.12
	Group B6 (Autoclave)	5	717.8340	51.45482	23.01129	653.9444	781.7236	630.49	752.27
	Total	**30**	**726.0437**	**31.17085**	**5.69099**	**714.4043**	**737.6831**	**630.49**	**768.19**

TABLE 3: Comparison of mean value and standard deviation of Tensile Strength (Newton) & Elongation (percentage) of Intraoral Elastics

The data was analysed using Analysis of Variance Test (ANOVA) that was used to determine whether significant differences were present in tensile strength and elongation values between all the test groups of Elastomeric Chain & Intraoral Elastics. Statistical analyses were conducted at a significance level of P<0.05.

In the Group A: Elastomeric Chain, Analysis of Variance (ANOVA) show there was statistically significant difference in tensile strength and elongation of elastomeric chain between control and test group. As the significance level of tensile strength and elongation is P=0.000 which is less than the significance level of P>.05. **Table 4**show the Analysis of Variance (ANOVA) test of Elastomeric Chain.

ANOVA						
ELASTOMERIC CHAIN		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
TENSILE STRENGTH	Between Groups	226.159	5	45.232	9.601	**0.000**
	Within Groups	113.068	24	4.711		
	Total	**339.227**	**29**			
ELONGATION	Between Groups	122313.609	5	24462.722	21.501	**0.000**
	Within Groups	27305.462	24	1137.728		
	Total	**149619.072**	**29**			

TABLE 4: Analysis of Variance (ANOVA) show the significant difference in tensile strength and elongation of Elastomeric chain

In the Group B: Intraoral Elastics, Analysis of Variance (ANOVA) shows statistically significant difference in tensile strength in elastics, but not statistically significant in elongation of elastics. As the significance level of tensile strength is P=0.029 which is less than the significance level of P>.05 and significance level of elongation is P=0.127 which is higher than the significance level of P>.05. **Table 5** shows the Analysis of Variance (ANOVA) test of Intraoral Elastics.

ANOVA						
INTRAORAL ELASTICS		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
TENSILE STRENGTH	Between Groups	156.531	5	31.306	3.031	0.029
	Within Groups	247.888	24	10.329		

	Total	**404.419**	**29**			
ELONGATION	Between Groups	8078.999	5	1615.800	1.930	0.127
	Within Groups	20098.032	24	837.418		
	Total	**28177.031**	**29**			

TABLE 5: Analysis of Variance (ANOVA) show the significant difference in tensile strength and elongation of Intraoral Elastics

Multiple comparison was done by using Dunnet 't' (2-sided) test, in this there was a comparison of one group as a control with the all-other groups.

In Dunnet 't' (2-sided) test of Group A (Elastomeric Chain), there was a statistically significant difference in Control Group V/s Group A4 (1% peracetic acid) and Group A6 (autoclave) with respect to tensile strength whereas there was significant difference in elongation between control group and all other groups. **Table 6**shows the multiple comparison of tensile strength and elongation of control group with the other groups of Elastomeric Chain.

In Group B (Intraoral Elastics), there was a statistically significant difference in tensile strength between the Control Group V/s Group B2 (2% Glutaraldehyde), Group B4 (1% peracetic acid) and Group B5 (Hot water). **Table 7**shows the multiple comparison of tensile strength and elongation of control group with the other groups of Intraoral Elastics.

Multiple Comparisons (Elastomeric Chain)							
Dunnett 't' (2-sided) [a]							
Dependent Variable	**(I) Group**	**(J) Group**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
						Lower Bound	**Upper Bound**
TENSILE STRENGTH	A2	A1	3.08000	1.37276	0.126	-.6200	6.7800
	A3	A1	.06000	1.37276	1.000	-3.6400	3.7600
	A4	A1	4.12000*	1.37276	**0.025**	.4200	7.8200
	A5	A1	2.26000	1.37276	0.356	-1.4400	5.9600
	A6	A1	8.08000*	1.37276	**0.000**	4.3800	11.7800
ELONGATION	2.00	1.00	60.56000*	21.33286	**0.037**	3.0610	118.0590
	3.00	1.00	107.50000*	21.33286	**0.000**	50.0010	164.9990
	4.00	1.00	85.27400*	21.33286	**0.002**	27.7750	142.7730
	5.00	1.00	66.22400*	21.33286	**0.020**	8.7250	123.7230
	6.00	1.00	210.90200*	21.33286	**0.000**	153.4030	268.4010

TABLE 6: Comparison of tensile strength and elongation of control group with the other groups of Elastomeric Chain

Multiple Comparisons (Intraoral Elastics)							
Dunnett 't' (2-sided) [a]							
Dependent Variable	**(I) Group**	**(J) Group**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
						Lower Bound	**Upper Bound**
TENSILE STREGNTH	2.00	1.00	7.44000*	2.03260	0.005	1.9615	12.9185
	3.00	1.00	4.84000	2.03260	0.096	-0.6385	10.3185
	4.00	1.00	5.50000*	2.03260	0.049	0.0215	10.9785
	5.00	1.00	5.66000*	2.03260	0.041	0.1815	11.1385
	6.00	1.00	5.08000	2.03260	0.076	-0.3985	10.5585
ELONGATION	2.00	1.00	47.96000	18.30211	0.059	-1.3701	97.2901
	3.00	1.00	10.77000	18.30211	0.964	-38.5601	60.1001
	4.00	1.00	36.88800	18.30211	0.193	-12.4421	86.2181
	5.00	1.00	16.51000	18.30211	0.834	-32.8201	65.8401
	6.00	1.00	12.57400	18.30211	0.935	-36.7561	61.9041

TABLE7: Comparison of tensile strength and elongation of control group with the other groups of Intraoral Elastics

Discussion

Elastomeric chains were first introduced to the field of dentistry in the 1960s and have since become essential in numerous orthodontic practices[3].In orthodontic treatment, intraoral elastics are employed to facilitate the desired movement of teeth and to ensure proper anchorage throughout the process. They are essential in orthodontics, as they apply forces to the teeth and jaws, aiding in the treatment of malalignment[12].

Elastics are frequently utilized alongside braces or other orthodontic devices to assist in the proper alignment of teeth. Depending on the individual treatment plan, they may be affixed to brackets on the teeth or to hooks on orthodontic wires. These elastics function by exerting a consistent force on the teeth, gradually directing them into the intended position[12].

The practices of sterilization and disinfection are the essential components of any infection control programme during a healthcare setting. Although elastomeric chains are widely accepted and utilized, there remains a degree of uncertainty regarding their mechanical and biological properties following sterilization and disinfection processes.

The objective of the current research was to investigate how sterilization and disinfection influence the tensile strength of orthodontic elastomers. For this purpose, Elastomeric Chain and Intraoral Elastics were chosen and organized into two groups, each containing 30 samples. Each group was then organized into six sub-groups according to the different sterilization and disinfection methods employed: Control Group; 2% Glutaraldehyde; 70% Alcohol; 1% Peracetic Acid; Hot Water (70°) and Autoclave.

This study's results revealed that in the Elastomeric chain group, there was a statistically meaningful difference in tensile strength when comparing the comparision group to the 1% peracetic acid and autoclave. Additionally, in the Intraoral Elastic group, a Statistically meaningful difference in tensile strength was found between the control group and the 2% glutaraldehyde, 1% peracetic acid and hot water.

Pithon et al. (2015) performed a study aimed at examining the impact of various sterilization and disinfection techniques on mechanical characteristics of orthodontic e-chains. The sterilization methods evaluated included a control group, 70% alcohol, autoclaving, ultraviolet light, peracetic acid and glutaraldehyde. The findings indicated that, with the exception of the ultra-violet method, all other techniques effectively sterilized the e-chains without causing any deterioration in their mechanical properties[11].

In the research carried out by **Jeffries & Fraunhofer (1991)** regarding the impact of a 2% alkaline glutaraldehyde solution on the elastic characteristics of elastomeric chains, two brands, Sporicidin and Cidex-7, were utilized for the cold sterilization of these materials. The findings indicated that the use of glutaraldehyde solution for cold disinfection and/or sterilization could serve as an effective and practical method for treating elastomeric chains[5].

Barati et al. (2021) performed a study aimed at comparing the impact of peracetic acid and glutaraldehyde on the tensile load at failure of e-chains following disinfection. A total of 30 e-chains were organized into three groups: a control group, a glutaraldehyde group and a peracetic acid group. The tensile load at failure was recorded using a universal testing machine. The findings indicated that there were no significant differences between the two disinfectants[2].

Evangelista et al. (2007) performed a study aimed at assessing the impact of various disinfecting solutions on the mechanical characteristics of orthodontic elastomeric ligatures. The solutions tested included those from American Orthodontics (AO), 3M and Rocky Mountain (RMO), specifically glutaraldehyde at a concentration of 3.4%, as well as Vital Defense-D, which contains 9% o-phenylphenol and 1% o-benzyl-p-chlorophenol [Vital Defense Company], applied over different exposure durations. Their findings indicated that the tensile load to failure of elastomeric ligatures diminished when these ligatures were subjected to disinfectant solutions for one hour or longer, a result that aligns completely with the findings of our current study[4].

Conclusion

The study concluded that a significant decline in the tensile strength of elastomeric chains is observed when subjected to peracetic acid and autoclave treatment; however, the reduction is comparatively minor when exposed to glutaraldehyde, alcohol, and hot water.

While the Intraoral Elastics demonstrate a marked decline in tensile strength when treated with glutaraldehyde, peracetic acid and hot water, though the reduction is less significant in the group of alcohol and autoclave sterilization.

The findings of this study indicate that orthodontists utilizing elastomeric chains and intraoral elastics should be mindful of the tensile strength of orthodontic elastomers following sterilization and disinfection processes.

The statistically significant differences observed in the study regarding the sterilization and disinfection of orthodontic elastomers lead us to conclude that alcohol, 2% glutaraldehyde, and hot water are suitable for the sterilization of Elastomeric Chains, while alcohol and autoclaving are appropriate for Intraoral Elastics.

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