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Original Research Article

Effect of chlorhexidine mouth rinse in force decay of closed, short and long elastomeric chain - An in vitro study

Rohan Jacob Sam[1,*], Vaibhav Mishra[2], Ashish Yadav[2], Deepanshi Yadav[2], Divya Joshi[2], Kshetrimayum Martina[2]

[1] *Dept. of Dental, Dr. Bhimrao Ambedkar University, Agra, Uttar Pradesh, India*
[2] *DJ College Of Dental Sciences & Research, Modinagar, Uttar Pradesh, India*

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ABSTRACT

Introduction: Elastomeric chain is one of the most commonly used orthodontic material, Evaluating the force transmission ability of elastomeric chains is essential so that orthodontists can estimate the actual force transferred to the dentition. The aim of this study was to assess effect of chlorhexidine mouth rinse on force decay of continuous, short and long elastomeric chain in chlorhexidine mouth wash.

Materials and Methods: The sample consisted three commercially available Orthodontic elastomeric chain (American Orthodontics, clear) such as continuous, short and long. These elastomeric chains were analysed with one experimental group and one control group. In control group all the three types of chain were dipped in distilled water for 30 second every day while in experimental group these elastomeric chains were dipped in mouth wash (Clohex Mouth Wash ADS) for 30 second every day. The result was tested by digital dynamometer and was statistically evaluated using ANOVA test.

Result: Continuous elastomeric chain showed least force decay in both experimental and control group throughout the study. In the inter group comparison there was significant difference of force decay between elastomeric chains with the control group and experimental group in the 3^{rd} week in both continuous and short elastomeric chain, experimental group showed more force decay.

Conclusion: Mouthwash does not accelerate force degradation of elastomeric chains which could clinically affect their effectiveness. However, the results could be variable in the presence of other biological factors in the oral environment and their interactions between oral microorganisms with the host.

1. Introduction

With the advent of vulcanization by Charles Goodyear in 1839, uses for natural rubber greatly increased. Early advocates of natural latex rubber elastics in orthodontics included Baker, Case, and Angle.[1] Synthetic elastomeric chains have been used by orthodontists since the 1960s. These polyurethane materials have largely replaced latex elastics for intra arch tooth movement. The plastic modules are designed for use in the correction of tooth rotations and the closure of space. Force decay in these materials is significant and has been a clinical problem.[2]

In 1846 Baker in an article in New York Dental Recorder titled "The use of Indian rubber in regulating teeth", explained the use of a thin sheet of Indian rubber to regulate tooth movement on which it was fastened. However, after Henry A Baker mentioned the use of elastics to exert Class II intermaxillary force (Baker's Anchorage), the use of elastics in orthodontics gained immense popularity.[3] They are used to generate light continuous forces for canine retraction, diastema closure, rotational correction, and arch construction. On the other hand, they were made

* *Corresponding author*.
E-mail address: rohanjacobsam666@gmai.com (R. J. Sam).

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of industrial polyurethanes which were not inert materials so with long-drawn-out contact with enzyme, water or heat they will decompose.[4]

The disadvantage of elastomeric chain is the rapid relaxation of force, due to breakage of cross links between the long chain molecules, that occurs in first 24 hours of clinical use.[5] These chains are prone to fatigue during use and the amount of force exerted by them will be reduced and this process will be intensified in the oral cavity environment.[6]

When stretched and exposed to the oral environment, the chains may absorb humidity and suffer a breakdown of internal bonds, which leads to permanent deformation. Extensive literature now exists on the properties, behaviour, and modes of action of elastomeric chains, emphasizing that thermal cycled samples experienced less force decay than samples stored at room temperature.[7]

Mouthwashes are prescribed widely for patients with a fixed orthodontic appliance in addition to the tooth brush and interdental aids. Chlorhexidine is considered the superior mouthwash although it has many side effects like tooth discoloration, taste disturbance, desquamation of the mucosa, and augmentation of calculus deposition.[7] Evaluating the probability of force transmission disability in systems is essential because in such situations the orthodontist cannot estimate the actual force transferred to the dentition, considering the probable effect of mouthwashes on reducing elastomeric chain forces.

2. Materials and Methods

This in-vitro study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics in D J Dental College and Hospital, Modinagar.

Materials used in the Study: The sample for this in-vitro study consisted of Orthodontic elastomeric chain (American Orthodontics, clear)- (continuous, short, long) (Figure 1). (The elastomeric chains will be divided into experimental group and control group each containing 20 elastomeric chains of continuous, short and long. Thus, the total sample taken will be 120 elastomeric chains), Chlorhexidine mouth rinse (Clohex Mouth Wash ADS) (Figure 2), Distilled Water, Artificial Saliva (Figure 3), Jigs, Digital Dynamometer (Figure 7), Incubator (Figure 8), Digital Timer and two acrylic sheets measuring 15cm X 15cm X 1cm will be fabricated. The sheets will be consisting of 3 rows and 20 columns of 120 stainless steel pins (Figure 5). The stainless-steel pins were stabilized and were used to hold the stretched elastomeric chains at constant length. The chains were cut into pieces consisting of 7 loops from continuous, 6 loops from short, and 5 loops from long then divided into 6 groups. All elastomeric chains were pre-stretched twice its resting length to avoid force decay. Elastomeric chain was stretched so as to apply a force of 200g which was measured with digital dynamometer. The control and test groups were independently submerged separately in 37°C artificial saliva (Figure 6), in order to simulate the oral conditions. Both the group was housed in an incubator and maintained at room temperature using thermostat. The control group was submerged in Distilled Water. Similarly, the test specimens were submerged in the test solutions i.e., chlorhexidine mouth rinse for 30 seconds, twice daily for the entire test period (Figure 4). Each 30 second exposure of the test specimens was measured using a digital clock. After being submerged in the solution, specimens were dipped in separate, distilled water baths for 10 seconds to simulate rinsing of the mouth rinses from the oral cavity. These specimens were then placed back into artificial saliva at 37°C. Data collection: Six test measurements of the remaining force values was made at the following time intervals: baseline (0), 1, 7, 14, 21, and 28 days. Force measurements was obtained with a Digital Dynamometer. Measurements was made by leaving one end of the elastomeric chain secured on the pin and fixing the other to the force tester, allowing for the measurement of the tensile force. Measurement readings was taken with the elastomeric chain stretched to the same length that the jig pins had previously maintained them. All chains were handled and measured in the same manner at the same vertical and horizontal distance on the jig board to ensure consistent measurements. Statistical test: The effects of group (Distilled water and Chlorhexidine mouth rinse) and time (initial, 1, 7, 14, 21, and 28 days) on force was analysed with a two-way analysis of variance (ANOVA).

3. Result

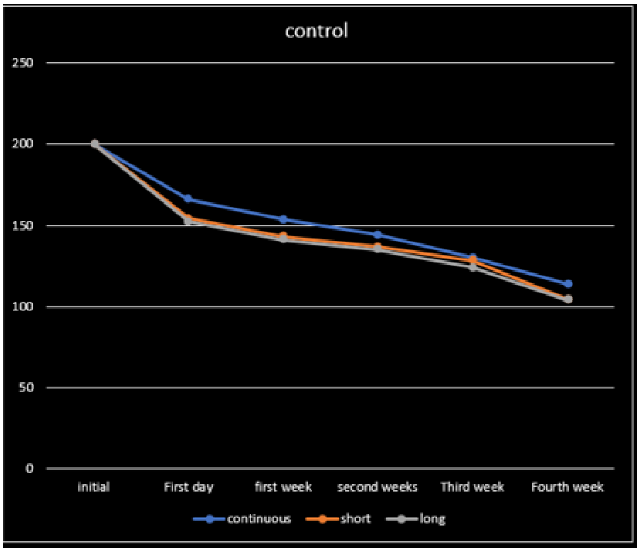
In this experiment factors influencing force decay of elastomeric chains, were time duration, type of elastomeric chain and exposure to test solutions. continuous elastomeric chains have the least amount of force decay in both experimental and control group.

Inter group comparison also shows a trend of more force decay in experimental group when compared to control (Tables 1 and 2). In the third week, significant difference between continuous e- chain in control (130.50 gm) and continuous e chain in experimental (126 gm) was seen.

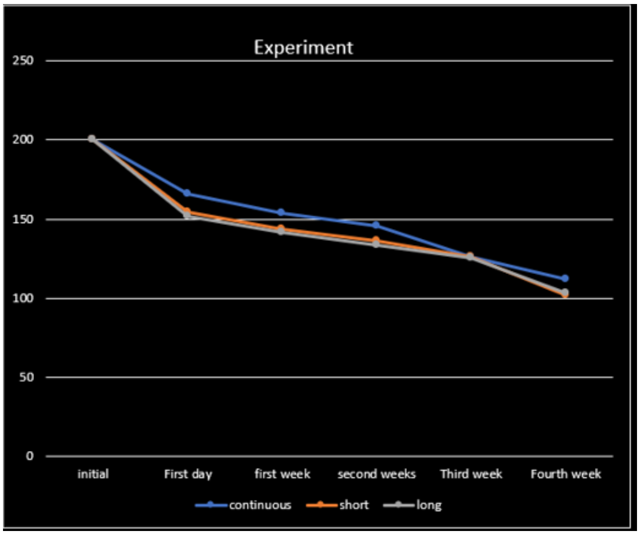
Significant difference between short e-chain (128.5) in control and short e-chain (126) in experimental was also observed in the third week. There was significant difference of force decay between elastomeric chains with the control group and experimental group in the 3^{rd} week in both continuous and short elastomeric chain with p value of 0.001 and 0.025 respectively. Continuous elastomeric chain has significantly less force decay when we compare with short and long during the entire study period. Short and long elastomeric chains show significant difference only in third week with p value of 0.003. A sudden drop in force in the first 24 hours and from first week the force decay reduced in the entire study period (Graphs 1 and 2).

Table 1: Mean tensile strength at each time interval fromday 0 to Day 28

Type of e chain at diff time interval	Group	Mean
continuous-day one	Control	166.00
	Experimental	166.00
short- day one	Control	154.50
	Experimental	154.25
long- day one	Control	152.25
	Experimental	151.75
continuous-1week	Control	153.75
	Experimental	154.00
short-1st week	Control	143.25
	Experimental	143.45
long-1st week	Control	141.25
	Experimental	141.50
continuous-2^{nd} week	Control	144.25
	Experimental	146.00
short-2^{nd} week	Control	136.75
	Experimental	136.50
long-2^{nd} week	Control	135.00
	Experimental	133.50
continuous-3^{rd} week	Control	130.50
	Experimental	126.00
short-3^{rd} week	Control	128.50
	Experimental	126.00
long-3^{rd} week	Control	124.50
	Experimental	125.50
continuous-4^{th} week	Control	114.25
	Experimental	112.25
short-4^{th} week	Control	104.50
	Experimental	102.25
long-4^{th} week	Control	104.00
	Experimental	103.00



Graph 1: Mean force at each time interval of control group



Graph 2: Mean force at each time interval of experimental group

Table 2: Intergroup comparison of various types of e-chains among both of the studied groups.

Type of e chain at diff time interval	Group	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference
continuous-1	Control	.000	1.000	.000	1.158
	Experimental	.000	1.000	.000	1.158
short-1	Control	.228	.821	.250	1.099
	Experimental	.228	.821	.250	1.099
long-1	Control	.531	.599	.500	.942
	Experimental	.531	.599	.500	.942
continuous-1w	Control	-.252	.802	-.250	.992
	Experimental	-.252	.802	-.250	.992
short-1 w	Control	-.265	.793	-.200	.755
	Experimental	-.265	.793	-.200	.755
long-1 w	Control	-.309	.759	-.250	.809
	Experimental	-.309	.759	-.250	.809
continuous-2w	Control	-1.53	.133	-1.750	1.140
	Experimental	-1.53	.133	-1.750	1.140
short-2w	Control	.225	.823	.250	1.111
	Experimental	.225	.823	.250	1.111
long-2w	Control	1.371	.178	1.500	1.094
	Experimental	1.371	.179	1.500	1.094
continuous-3w	Control	3.509	.001	4.500	1.282
	Experimental	3.509	.001	4.500	1.282
short-3w	Control	2.337	.025	2.500	1.070
	Experimental	2.337	.025	2.500	1.070
long-3w	Control	-.839	.407	-1.000	1.192
	Experimental	-.839	.407	-1.000	1.192
continuous-4w	Control	1.241	.222	2.000	1.612
	Experimental	1.241	.223	2.000	1.612
short-4w	Control	1.208	.235	2.250	1.863
	Experimental	1.208	.235	2.250	1.863
long-4w	Control	.563	.577	1.000	1.777
	Experimental	.563	.577	1.000	1.777

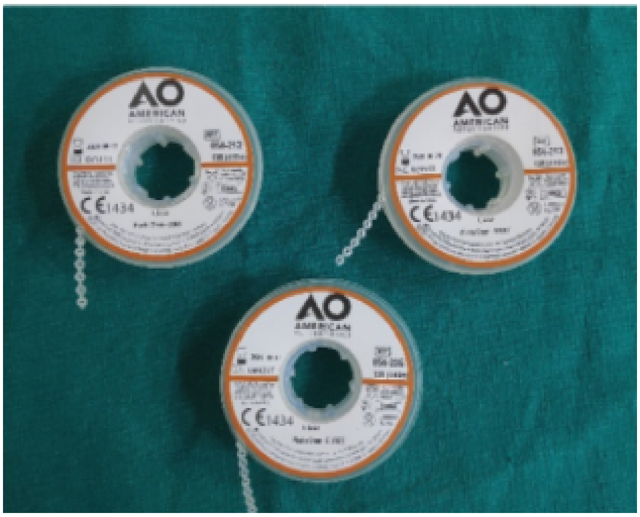


Fig. 1: Orthodontic elastomeric chain

Fig. 2: Chlorhexidine mouth rinse

Fig. 3: Artificial saliva.

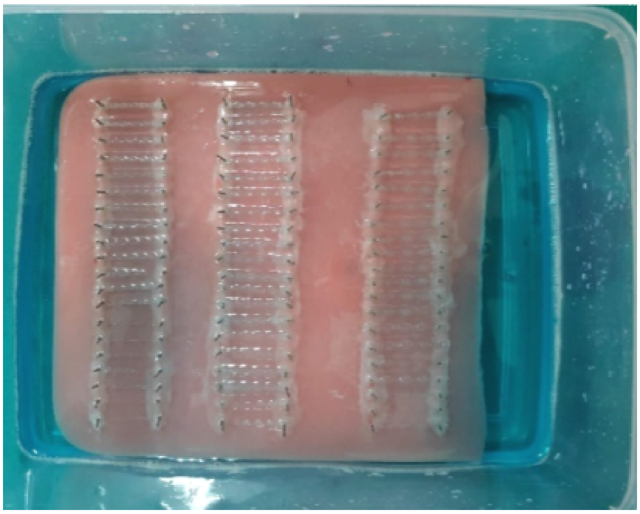


Fig. 4: Experimental group in mouth wash

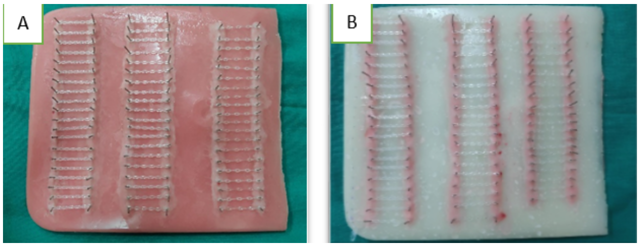


Fig. 5: Control (A) and Experimental roup (B)

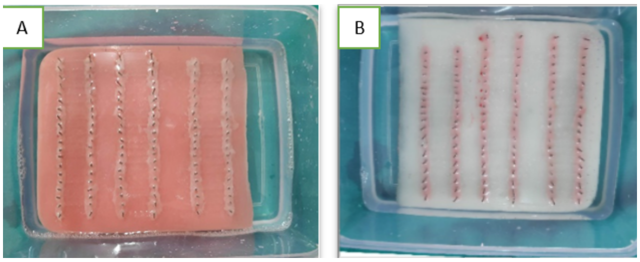


Fig. 6: Experimental (A) and control (B) in Artificial saliva

Fig. 7: Digitaldynamo meter

Continuous elastomeric chains had the least amount of force decay whereas force decay in long and short elastomeric chain were identical. Force decay in 1^{st} day, 1^{st} week, 2^{nd} week, 3^{rd} week and 4^{th} week were 17%, 6.1%, 4.75%, 6.8% and 8.12% in continuous control group respectively. Force decay in 1^{st} day, 1^{st} week, 2^{nd} week, 3^{rd} week and 4^{th} week were 17%, 6%, 4%,10%, and 6.8% in continuous experiment group respectively.

There was significant difference of force decay between elastomeric chains within the control and experimental group. Continuous elastomeric chain was having the least amount of force decay when compared with long and short elastomeric chain during the entire study period. In 3^{rd} week force decay of long e-chain was significantly less than short e-chain in control group.

Fig. 8: Incubator

In experimental group 2^{nd} week force decay of short e-chain was significantly less than long e-chain.

4. Discussion

Elastomer is a general term that encompasses materials that, after substantial deformation, rapidly return to their original dimensions. Natural rubber, probably used by the ancient Incan and Mayan civilizations, was the first known elastomer. With the advent of vulcanization by Charles Goodyear in 1839, uses for natural rubber greatly increased.[1] Synthetic rubber polymers, developed from petrochemicals in the 1920s, have a weak molecular attraction consisting of primary and secondary bonds. At rest, a random geometric pattern of folded linear molecular chains exists. On extension or distortion, these molecular chains unfold in an ordered linear fashion at the expense of the secondary bonds. Cross links of primary bonds are maintained at a few locations along the molecular chains.[8]

Elastomeric chains have their disadvantages. When exposed to an oral environment, they absorb water and saliva, permanently stain, and suffer a breakdown of internal bonds leading to permanent deformation.[9] They also experience rapid loss of force due to stress relaxation, resulting in a gradual loss of effectiveness.[10] Clinical observations have shown that the elastomeric materials are permanently elongated and undergo plastic deformation.[11] This deformation is related to many things such as the amount of time as well as amount of stretch given to the materials.[12]

Use of orthodontic appliance demands special care from wearer because the presence of this device in the oral cavity leads to greater accumulation of the bacterial plaque around the brackets and bands. In addition to mechanical control, it is important to implement chemical plaque control also.[7] Among antiseptics for oral use, Chlorhexidine is one of the most powerful and most studied antimicrobials but has the disadvantage of staining teeth.[13]

Since the 1970's, several studies have been published on the decay of elastomers in the oral cavity during orthodontic treatment. The results of various studies on orthodontic elastics have shown wide range of force decay (24% - 85%) after 28 days.[10] Some of the reasons behind these results may include difference in the media in which the samples were tested and quality of the elastomeric chains used.

Years ago, Genova et al.[2] evaluated the behaviour of elastics over a period of 3 weeks. However, a period of 4 weeks was selected for the study because it coincides with the time interval between orthodontic consultations, the same period was observed by Motta et al.[14]

Because this present study concerns a simulation of the oral cavity, artificial saliva was used and as it is known that the temperature participates in the force degradation of the elastics[15] the temperature at which the elastics were maintained was 37± 1°C. Bishara and Andreasen in 1970 stated that no significant difference in force degradation of elastomeric chains existed when materials were tested in water or in saliva.10] Artificial saliva has been used as a medium in other studies also done by Genova D C,[2] Pithon.[16] and Larrabee.[17] Therefore, the chain elastic segments were kept immersed in artificial saliva.

In this study the chains were cut to pieces consisting of 7 loops from continuous, 6 loops of short, and 5 loops of long then divided into 6 groups, each group contains 20 elastomeric chains. According to the study by Brantely et al[18] and Young et al[19] all elastomeric chains have to be pre stretched 100% before using to avoid sudden force decay so elastomeric chains were pre-stretched twice it's resting length to avoid sudden force decay. Elastomeric chain is then stretched so as to apply a force of 200g which was measured with digital dynamometer. The optimal force required for canine retraction as stated by De Genova DC et al[2], Eliades et al[20] in their studies was also 100 gm - 250 gm. Continuous, short and long were stretched 21mm, 23mm and 24mm respectively This distance was measured by stretching specimens to produce 200gm of force by dynamometer. This is similar to the mean distance of maxillary canine to maxillary first molar on same time of dental arch according to Hassan et al.[7] Although elastomeric chains are widely used in orthodontics for tooth movement and close the space, force loss over time is inevitable. Several studies have examined the force degradation of elastomeric chains.[21–24] Then the control and the test groups were independently submerged in 37°C artificial saliva, in order to simulate the oral conditions which is the intra oral temperature of oral cavity.[25] The control group was submerged in distilled water for 30 seconds and the test specimens was submerged in chlorhexidine mouth rinse for 30 seconds, twice daily for the entire test period. After being submerged in respective solutions, specimens were dipped in separate distilled water baths for 10 seconds to simulate rinsing of the mouth rinses from the oral cavity. These specimens were then placed back into artificial saliva at 37°C. Force measurements were obtained with a Digital Dynamometer. Measurements were made by leaving one end of the elastomeric chain secured on the pin and fixing the other to the force tester, allowing for the measurement of the tensile force. Measurement readings taken with the elastomeric chain stretched to the same length that the jig pins had previously maintained. All chains were handled and measured in the same manner at the same vertical and horizontal distance on the jig board to ensure consistent measurements.

Based on the results obtained in this study, there is about 17% to 24% of force decay of e-chains within 24 hours. An optimum residual force of 113-103 gm was present till the end of 28 days which means 42% to 48% of force reduction have occurred. In the first 24 hours there was a sudden drop in the force in all three types of e chains both in control and experimental group and after 24 hours the force decay became stable throughout the study period. This result is similar to the studies conducted by Nattrass et al,[26] Dittmer et al,[27] Samules et al[28] and Balhoff et al.[29]

Among all the experimental groups, it was observed that the force degradation of Elastomeric chains was least in continuous elastomeric chains (87.75 gm) followed by long (97.25 gm) and short (97 gm). control group is also having similar result that is force degradation was least in continuous (85.75 gm) followed by short (95 gm) and long (96 gm) e-chains which was similar with the study done by Mousavi et al.[12]

Even though there was difference in the force decay between control and experimental group significant change was seen only in the third week. In the third week force decay in continuous and short in control was significantly less than that of experimental group.

In the Chlorhexidine group, showed more degradation of force than compared to control. In this study it was observed that there was significant difference in the force degradation in all three types of elastomeric chain.

In this study it was observed that Chlorhexidine mouthwash do not accelerate force degradation of elastomeric chains which could clinically affect their effectiveness. However, the results could be variable in the presence of other biological factors in the oral environment. Further laboratory studies should simulate the clinical conditions of the oral cavity to determine the effects of changes in pH, temperature, intake of food, beverages, contaminants etc on the tensile strength of the elastomeric chains.

Performance of the elastomeric chain could not simulate the degradation seen in-vivo because this study was done under static condition in vitro, more studies need to conducted in clinical situation, where varied oral environment due to different stretching, dietary habits, and microbial activity was present. This would allow us a better understanding of the physical properties of elastic materials under different clinical conditions. Further study is needed using different brands of elastomeric chains also. Therefore, although the present findings were useful guide to the anticipated clinical behaviour of the elastomeric chains, the observed clinical behaviour may differ.

5. Conclusion

In this in-vitro study, one control group i.e., Distilled Water (GROUP 1) and one experimental group Mouthwash (GROUP 2), were used to evaluate their effect on the tensile strength of commercially available three type of elastomeric chain. Based on the analysis of the results obtained and limitations of the study the following conclusions were drawn. The force degradation was rapid in first 24 hrs. followed by gradual degradation over the next 28 days. The force degradation was least in continuous elastomeric chain in control followed by continuous in experimental group. Force degradation was more in experimental group at the end of 28 days, but significant difference was seen in the 3^{rd} week between continuous and short.

It is thereby concluded in our study that Chlorhexidine mouthwashes do not accelerate force degradation of elastomeric chains which could clinically affect their effectiveness. However, the results could be variable in the presence of other biological factors in the oral environment and their interactions between oral microorganisms with the host. Duration and type of elastomeric chain were found to be the most important factor in influencing force decay followed by mouthwash.

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7. Conflict of Interest

None.

8. Source of Funding

None.

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Author biography

Rohan Jacob Sam, Post Graduate Student

Vaibhav Mishra, Professor & Head

Ashish Yadav, Reader

Deepanshi Yadav, Senior Lecturer

Divya Joshi, Senior Lecturer

Kshetrimayum Martina, Post Graduate Student

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