

The Force Decrease Differences Between ISO-Standardized and Non-ISO-Standardized Long and Short Power Chain

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Abstract: Power chain is one of auxiliaries used in orthodontic treatment primarily for teeth retraction. The force generated by power chain decays over time and about 13%-75% of the initial force is lost in the first 24 hours. The level of force decrease depends on several conditions, mostly the type, quality, and size of the power chain. In this study, 4 rolls of power chain (ISO-standardized long power chain, ISO-standardized short power chain, non-ISO-standardized long power chain, and non-ISO-standardized short power chain) were cut to a specific length. 4 multiplex boards with 10 lines of pins with 2 pins facing each other within 10mm distance were used to stretch the chain. The boards were then incubated in artificial saliva at 37°C for 21 days. The initial force was recorded at day 0 and the force decrease was recorded 3 times at day 1, 14 and 21. The data were analyzed by ANOVA test and compared using the ANOVA. There was a statistically significant difference between specimens groups regarding the force decrease. All groups showed force decrease over time, regardless of their length in both ISO-standardized and non-ISO-standardized power chain. On the first day the force loss of 35-40% was observed and up to 55% after 21 days of activation.

Keyword: Force decrease, long power chain, short power chain, ISO-standardized and non-ISO-standardized

1. Introduction

Tooth extraction, molar distalization, skeletal and dental arch expansion, interproximal decrease, and other measures are part of space-acquiring orthodontic treatment methods performed to correct malocclusion. But in some cases, the procedure produces a space that must be corrected later by the orthodontist. The closure of space which occurs from tooth extraction may need the elastomeric chain products such as power chains^{1,2,3}. Power chain is chosen because of the easy handling, affordable price, comfort provided for the patient, and hygienic state^{4,5}.

Several previous studies said that power chains have decreasing retraction force within the first 24 hours after the application and activation, with the most decrease happening in the first hour. It will then slowly decreasing for 3-4 weeks later⁶. Hershey and Reynold (1975) and Buchman (2011) stated that the force was decreasing around 50-70% after 28 days. In other study, De Genova (1985) and Da Silva (2009) explained that there was already a decrease in the force of power chain in around 44-60% on the first 21 days after power chain application. This decrease in force depends on several conditions, including the composition, size, and the quality of the power chain⁷.

The International Organization for Standardization (ISO) is an international non-governmental organization that develops international standards. The ISO technical committee (TC) is tasked with standardizing terminology, testing methods and determining material specifications for dental equipment at the international level. A material with proficient quality and safety is determined based on the guidelines of internationally recognized quality standards in the form of ISO certification. The ISO standard is used to determine the quality of orthodontic treatment equipment

and materials, including the power chain. It is expected that an ISO-standardized power chain will have better quality and thus lesser force decrease when used.

The orthodontic treatment done in the Orthodontic PPDGS clinic in RSGM UNPAD use a plentiful amount of power chain. Based on the presented facts above the authors are interested in conducting research on the comparison of the force decrease between ISO-standardized and non-ISO-standardized long and short power chain on day 0, 1, and 21.

2. Material and methods

This was an experimental laboratory study undertaken at the Laboratorium Penelitian Terpadu of Padjadjaran University. A total of 40 samples was measured using the digital force gauge to find the amount of force decrease between ISO-standardized long power chain, ISO-standardized short power chain, non-ISO-standardized long power chain, and non-ISO-standardized short power chain at 37°C on day 0, 1 and 21. The research time was from May-June 2018.

Materials used in this study are: (1) ISO-standardized short transparent power chain (S-ISO) and non-ISO short transparent power chain (S-Non-ISO); (2) ISO-standardized long transparent power chain (L-ISO) and non-ISO-standardized long transparent power chain (L-Non-ISO); and (3) Artificial saliva to soak the power chain. Equipment used are: (1) A multiplex board with pins to hold the power chain; (2) A digital force gauge for measuring the force of power chain; (3) A temperature incubator to regulate the water temperature during immersion; (4) A plastic container in a size larger than the multiplex boards as a medium for immersion; and (5) A ligature wire cutter and Mathieu needle holder. Results were then analysed using the ANOVA method and presented in tables below.

3. Results

Based on the research that had been done, the data was obtained by calculating the average percentage of force decrease in all four types of power chain. The post-hoc analysis was done to assess differences significance between groups and presented in table 1 and table 2.

Table 1: Average power chain force decrease on day 0, 1 and 21 (in percentage)

Power Chain Type	Mean		N	Std. Dev	
	0 & 1	1 & 21		0 & 1	1 & 21
Short ISO (S-ISO)	41,03	28,13	10	4,04	5,59
Short Non-ISO (S-non-ISO)	48,28	54,81	10	2,53	3,59
Long ISO (L-ISO)	36,00	35,00	10	2,52	2,59
LongNon-ISO (L-non-ISO)	43,00	62,00	10	5,10	3,90

Table 2: Results of ANOVA test on power chain force decrease on day 0&1 and 1&21

Day	F	p-level
0 & 1	19.12	1.38E-07
1 & 21	154.34	1.32E-20

Table 3: Post-hoc analysis of power chain force decrease between day 0 and day 1

Power Chain Type	Mean	L-ISO	S-ISO	L-Non-ISO	S-Non-ISO
L-ISO	0.36				
S-ISO	0.41	.0027			
L-Non-ISO	0.43	.0015	.4723		
S-Non-ISO	0.48	1.92E-09	.0001	.0052	

Table 4: Post-hoc analysis of power chain force decrease between day 1 and day 21

Power Chain Type	Mean	S-ISO	L-ISO	S-Non-ISO	L-Non-ISO
S-ISO	0.28				
L-ISO	0.35	.0042			
S-Non-ISO	0.55	2.07E-10	2.31E-11		
L-Non-ISO	0.62	7.34E-12	4.49E-13	.0007	

Table 1 shows that there was a force decrease in power chain between day 0 and day 1, where the average decrease in power chain force is the greatest in S-Non-ISO by 48%, followed by a L-Non-ISO by 43%, S-ISO by 41%, and L-ISO by 36%. The decrease in power chain force between day 1 and day 21 showed the greatest decrease in power chain force occurs in L-Non-ISO at 62%, followed by S-Non-ISO at 54%, L-ISO at 35% and S-ISO of 28%. The ANOVA analysis showed that there was a statistically significant ($p < 0.05$) difference of average force decrease in all power chain types between day 0 and day 1 (Table 3) and day 1 and 21 (Table 4). Thus a post-hoc analysis was conducted to find out the difference between each group.

Table 3 showed that there was a statistically significant difference in power chain force decrease ($p = 1.38E-07$) between day 0 and day 1 between L-ISO & S-ISO, L-ISO & L-non-ISO, L-ISO & S-non-ISO, S-ISO & S-non-ISO, and L-non-ISO & S-non-ISO. There was no statistically significant force decrease between S-ISO & L-non-ISO. Table 4 shows that there was a statistically significant difference in force decrease ($p = 1.32E-20$) between day 1 and day 21 between L-ISO & S-ISO, S-ISO & S-non-ISO,

S-ISO & L-non-ISO, L-ISO & S-non-ISO, L-ISO & L-non-ISO, and L-non-ISO & S-non-ISO.

4. Discussion

Power chain has long been used in the orthodontic treatment and is an important component of force to aligning teeth and closing space, thus the wide usage of it in the field of orthodontics. This elastic material is not ideal because the force it produces will decrease within the period of activation^{6,8,9}. In this study, measurements of the decrease in power chain force were taken periodically, namely on day 1 and 21. The 1st-day measurement was done because the greatest decrease in force happened on day 1¹⁰. The 21st-day measurement was taken assuming that it is the patient's control time for activation in orthodontic treatment and to see the remaining force in the power chain^{11,12}.

The use of different power chain types was chosen because it was considered to represent options that might be used by orthodontists to close the remaining space after premolar extraction by retracting the canine, a common treatment plan for orthodontic patient⁸. The bodily movement of the canine requires a force of 70 & 120 grams depending on the surface area of the tooth root, yet the force is doubled twice to compensate friction due to the sliding mechanic movement¹³. Some literatures recommend the retraction of canines to close the space with forces of 100-200 grams^{14,15}. Therefore the initial force used in this study to test the power chain was under 200 grams.

The results of the study show that there is a significant difference of power chain force decrease between non-ISO-standardized and ISO-standardized power chain. All power chain samples showed a force decrease over the course of time, in accordance with the characteristics of not being able to produce a constant force¹⁶.

Measurement of the initial day 0 force showed all power chain samples producing force below 200 grams. Day 1 force measurements show the greatest decrease in force. The 21st-day measurement showed the smallest remaining force and the power chain condition has reduced in its elasticity. The result of this study indicate that there is a decrease in the initial force in the first 24 hours in all power chain types. This is similar to the study by Wong (1976) who stated that approximately 50% of the initial force is lost after being drowned at a constant amount of time at 37°C¹⁷.

The force decrease occurs when the power chain was stretched. This is due to the fact that polyurethane chain molecules, which have crosslink bonds, rub against each other. The crosslink molecule of polyurethane will initially pull the chain back to its original shape, but if left for a long period of time the crosslink bond will weaken and break after it reached the point of no return¹⁸.

One of the factors that influence the force decrease of power chain is the friction between the wire and bracket. When the canines were retracted, the teeth will move in tipping movement. This resulted in contact between the end of the bracket slot with the wire arc and binding occurs, then the teeth will stop moving. A decrease in force is required in this

condition to provide an opportunity for bone apposition so that the root follows the tipping movement of the crown. Other factors that influence the decrease in force from the power chain including optimal force for tooth movement, power chain shape and dimensions, distance of space closure, pre-stretching, and duration of activation^{16,19,13}.

5. Conclusion

Based on the result of this study:

- There are statistically significant force decrease differences between ISO-standardized and non-ISO-standardized short power chain on day 0&1 at 7.25% and on day 1& 21 at 26,68% where non-ISO-standardized short power chain has the most force decrease both on day 0 & 1 and 1 & 21.
- There are statistically significant force decrease differences between ISO-standardized and non-ISO-standardized long power chain on day 0&1 at 7% and day 1 &21 at 27%, where non-ISO-standardized long power chain has the most force decrease both on day 0&1 and day 1&21.
- There are statistically significant force decrease differences between ISO-standardized long and short power chain on day 0&1 at 21,97% and day 1& 21 at 6,87% where ISO-standardized short power chain has the most force decrease on day 0&1 and ISO-standardized long power chain has the most force decrease on day 1&21.
- There are statistically significant force decrease differences between non-ISO-standardized long and short power chain on day 0&1 at 5,28% and on day 1& 21 at 7,19% where non-ISO-standardized short power chain has the most force decrease on day 0&1 and non-ISO-standardized long power chain has the most force decrease on day 1 & 21.

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