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Original Article

Comparative Analysis of Tensile Strength between Three Types of Retraction Cords

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Abstract

Introduction: Gingival retraction is the withdrawal of the marginal gingiva away from the tooth. This procedure creates a space between the prepared tooth and the gingival tissues to catch more fine details of the impression material. The most common retraction device used in clinical practice is the retraction cord.

Aim: The study aims to evaluate the tensile strength of retraction cords designed with different braiding technology.

Materials and methods: A total of 150 experimental units were studied. They were divided into 3 groups of 50 each according to the type of retraction cord (Ultrapak #00, braided cord without core, and braided cord with monofilament core). We tested the tensile strength in the LMT 100 micro-tensile apparatus. The data were analyzed using SPSS v. 21. A critical significance level of $p<0.05$ is used.

Results: The comparative analysis of the tensile strength of the retraction cords shows a statistically significant difference between the braided and the knitted threads (Ultrapak #00) ($p<0.001$). The results indicated the highest tensile strength of the cord with monofilament 41.95 N/mm^2, followed closely by the cord with the same cotton braid without monofilament with average strength of 39.80 N/mm^2, and last came the Ultrapak cord 22.11 N/mm^2.

Conclusions: The braided retraction cords show higher tensile strength compared to the Ultrapak #00 cord, which is made using knitting technology.

Keywords

gingival retraction, physical properties, retraction agents

INTRODUCTION

The steps of making a fixed prosthesis include retraction of the gingival tissue, imprinting of the prosthetic field – prepared tooth, part or all of the row of teeth, together with the adjacent tissues, and registration of the antagonist teeth.[1-3] The first step, retraction or displacement of the gums, often uses a mechanical element placed in the gingival sulcus, such as a cord or paste.[4-6] The aim is to create a gap in the sulcus of about 0.2 mm.[7,8] Studies show that the retraction cord is the retraction device that dentists use the most.[9-12] The cords are classified according to their composition (cotton, silk or yarn, and wool), their impregnation with an astringent or hemostatic solution, and their design (twisted, knitted and braided).[13-16]

The success of fixed prosthetic restorations depends largely on the health and stability of the surrounding periodontal structures.[8,13] Due to aesthetic requirements, carious defects, previous old restorations, additional retention or other reasons, the edges of the fixed restorations are often located subgingivally, which necessitates correct and detailed impressions.[11]

The use of materials with insufficient properties, as well as inappropriate technique for the retraction of the gingival pocket can lead to irreversible changes in the gingival tissues.[17,18] Rupture of the retraction cord during its insertion or removal results in tearing of the tissue in the gingival sulcus and trauma to the connective tissue.[19] The reason for this may be the insufficient tensile strength. It is crucial for the retraction laces and their satisfactory physicochemical properties.[20,21]

AIM

The objective of this study was to evaluate the tensile strength of the two types of retraction cords made with different braiding technology and to compare it with a retraction cord from the market.

MATERIALS AND METHODS

The retraction cords used in this study were Ultrapak #00 (U) – Ultradent Products, South Jordan, Utah, USA **(Fig. 1)**, as well as two braided retraction cords offered by us **(Fig. 2)**:

1. 100% cotton braided cords without core (BC)
2. 92% cotton and 8% polyamide braided cords with monofilament core (BCM).

Figure 1. Ultrapak #00 retraction cord.

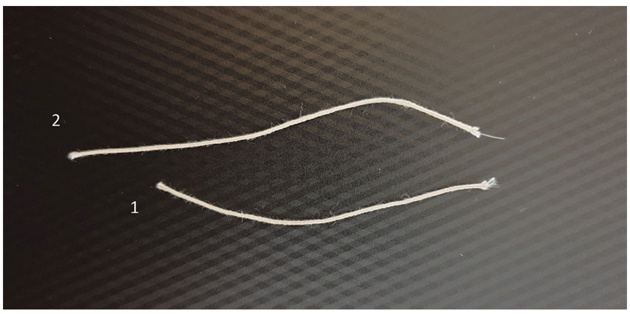

Figure 2. Braided retraction cord.

The braided cords are produced on a circular braiding machine by Herzog (Germany) with 8 carriers using braiding system. The even number of braiding carriers shapes a round braid **(Fig. 3)**.

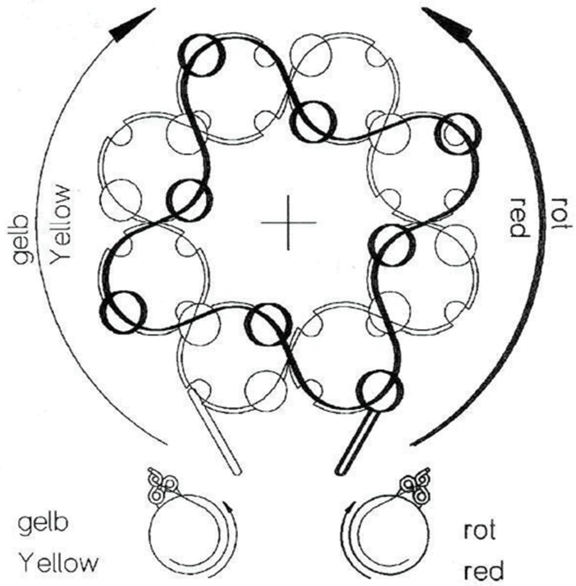

Figure 3. Diagram of circular braiding machine, Herzog (Germany).

The item is made in raw form and is subjected to additional physicochemical treatment and sterilization. A total of 150 experimental units were made, 50 from each group of retraction cords – U, BC, and BCM, according to the silicone matrix we made (Silibest, BMS Italy). The prepared prototype units were fixed on a round polypropylene pad. A cuff of pink plaque wax 20 mm high and 1.5 cm thick was placed around the pad. The prepared setup was filled with laboratory silicone for model duplication (Elite Double 22, Zhermack Italy) **(Fig. 4)**.

After elasticizing the silicone mass, the wax prototypes were removed, and thus the finished shape for making the future prototypes was obtained. The tested retraction cords were placed in the vacated nests, and they were fixed with epoxy resin (Epovit, Vector) **(Fig. 5)**.

The tensile strength test was performed in a LMT 100 micro-tension apparatus (LAM Industry, Italy) **(Fig. 6)**.

The data were analyzed using SPSS v. 21. The statistical methods used to analyze the information are descriptive analysis by means of two-dimensional frequency distribution tables (cross-tabulation) and analysis of variance (one-way ANOVA). A critical significance level of 0.05 is used.

RESULTS

The comparison of the average strength of the three types of retraction cords shows that the cord with monofilament had the highest tensile strength of 41.5±0.47 N/mm^2, followed

Figure 4. Stage of making the final matrix shape.

Figure 5. Making the final shape of the test specimens.

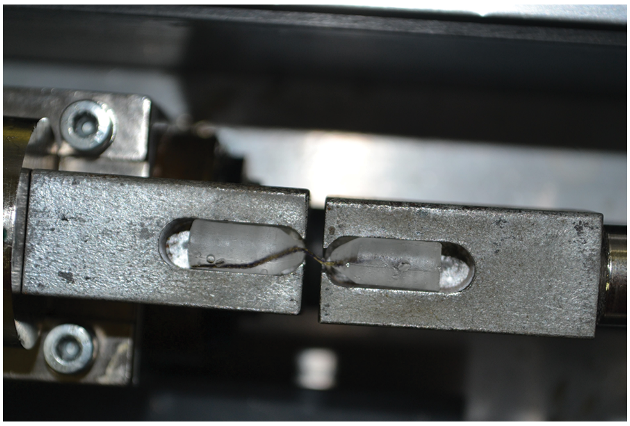

Figure 6. Prototype in the retaining elements of the LMT100 micro-tension apparatus.

closely by the cord with the same cotton braid without monofilament with average strength of 39.80±0.89 N/mm^2, and the Ultrapak cord with strength of 22.11±0.62 N/mm^2.

The average tensile strength of the experimental units was the highest in the monofilament cords compared to the other two types – 41.95±0.41 N/mm^2. With 95% confidence interval, the average force required to break the connection of a monofilament-core cord was 41.11 N/mm^2 as lower limit and 42.74 N/mm^2 as upper limit. The minimum reported breaking force was 33.1 N/mm^2 and the maximum 45.4 N/mm^2 **(Fig. 7)**.

The average tensile strength of the experimental cord without a core was 39.80±0.89 N/mm^2. With 95% confidence interval, the average force required to break the connection in the case of cotton thread without core was 38.04 N/mm^2 as lower limit, and 41.57 N/mm^2 as upper limit. The minimum reported breaking force was 23.6 N/mm^2 and the maximum 50.8 N/mm^2.

The average tensile strength of the experimental Ultrapak cords was the lowest (22.11±0.62 N/mm^2) compared to the other two types. With a 95% confidence interval, the

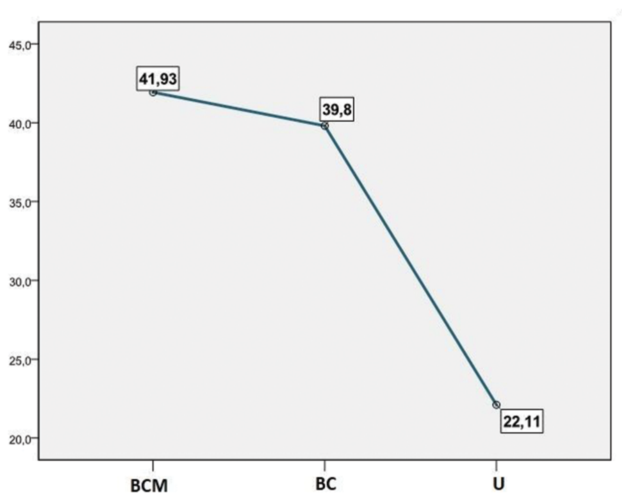

Figure 7. Comparison between the type of retraction cord and the tensile strength.

average force required to break the connection of the Ultrapak cord was 20.86 N/mm^2 as lower limit and 23.36 N/mm^2 as upper limit. The minimum reported breaking force was 13.0 N/mm^2 and the maximum 30.5 N/mm^2.

The multiple comparisons show a statistical difference between the compared groups according to numerical criterion. Distribution of the three groups, by analysis of variance (one-way ANOVA), confirmed a statistical difference in the group BCM and BC, where p=0.025. When comparing BCM and U, a statistically significant difference was found, where p<0.001, at F=267.92. We can also conclude that the distribution, by analysis of variance (one-way ANOVA), and in the comparison of BC and U, there was a statistical difference, where p<0.001, at F=267.92. The analysis revealed a statistically significant difference in the comparison of the tested test specimens of the three types of retraction cords (BC, BCM and U) for tensile strength.

DISCUSSION

Retraction cords are useful clinical aids, but there is insufficient information on the desired physical characteristics that would preserve their integrity during tension. This study aims to establish, under experimental conditions, the extent to which tensile strength is influenced by the braiding technology of the cords.

The obtained results show that the possible reasons for the higher values of the tensile strength of the two threads proposed by us (BS and BCM) compared to the Ultrapak cord can be found in their structure and composition. The applied effectiveness of the above retraction cords will have its real evidence after testing the two braided cords in a clinical environment.

One of the first studies to examine the physicochemical characteristics of retraction cords in more detail was by Nietro-Martinez et al. Their study established the effect of the impregnation substances and their concentrations on the tensile strength of the retraction cords, as well as the influence of the different diameters and number of threads of the cords. They come to the conclusion that the standard cotton cords are weakened when impregnated with aluminum sulfate and that they are even more weakened when using ferrous sulfate.[19]

The findings of another study by Madhok et al. are consistent with those of Nietro-Martinez et al.[19] They use aluminum and iron sulfates as hemostatic agents and conclude that they significantly reduce the tensile strength of the specimens.[19,20] The results of the Madhok study suggest that impregnating liquids have a “degrading effect” on the cords. The dissolution of the cotton fibers and reducing the tensile strength of the cords may be related to the low pH of the retraction agents they used.[20] This study examines only the relationship between the type of braiding of the retraction cords and their tensile strength. Subsequent studies must determine the effect of drug solutions on the stability of the cords.

In another study by Jokstad among dentists and dental students comparing braided and knitted cords, the knitted retraction cord was better ranked than the braided, as one of the evaluation criteria in this study was whether the cord frays during placement.[15] Zhan’s study shows good results for braided retraction cords when placed in the gingival sulcus and good ability to imbibate fluids.[22]

Gingival retraction is a routine procedure. However, it can cause gum injury due to improper application of the retraction techniques.[21] The few published studies on this subject comment that the likelihood of tearing and wear of the retraction cords is mainly due to their insufficient tensile strength.[19,20] The present study supports the findings of previous studies that insufficient tensile strength may be due to the cord’s mechanical structure (twisted, knitted, or braided), its chemical composition (cotton, silk, etc.), or the action of a chemical impregnating agent.[15,19,20]

The retraction cord must be strong enough to withstand the force of manipulating the gingival tissue, inserting and removing it from the gingival sulcus, in order to withdraw the gums before taking an impression.

CONCLUSIONS

Based on the results of the study, we come to the conclusion that the braided retraction cord with a monofilament core shows the highest tensile strength, followed by the braided thread without monofilament, while the knitted Ultrapak #00 has the lowest tensile strength. The difference is due to the structure and composition of the cords, which affect the durability of the retraction cords. Our results should be further tested in other non-clinical and clinical studies.

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Competing Interests

The authors have declared that no competing interests exist.

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Сравнительный анализ прочности на растяжение между тремя типами ретракционных нитей

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Резюме

Введение: Ретракция десны – это отведение маргинальной десны от зуба. Эта процедура создаёт пространство между отпрепарированным зубом и тканями десны, чтобы уловить более мелкие детали оттискного материала. Наиболее распространённым ретракционным устройством, используемым в клинической практике, является ретракционная нить.

Цель: Исследование направлено на оценку прочности на растяжение ретракционных нитей, изготовленных с использованием различных технологий плетения.

Материалы и методы: Всего было исследовано 150 экспериментальных единиц. Они были разделены на 3 группы по 50 человек в зависимости от типа ретракционной нити (Ультрапак # 00, плетёная нить без сердечника и плетёная нить с моноволоконным сердечником). Мы проверили прочность на растяжение в аппарате для микронатяжения LMT 100. Данные анализировали с использованием SPSS v. 21. Использовали критический уровень значимости $p<0.05$.

Результаты: Сравнительный анализ прочности на растяжение ретракционных нитей показывает статистически значимую разницу между плетёными и трикотажными нитями (Ультрапак # 00) ($p<0.001$). Результаты показали самую высокую прочность на растяжение нити с моноволокном 41.95 N/mm^2, за ней следует нить с такой же хлопчатобумажной тесьмой без моноволокна со средней прочностью 39.80 N/mm^2, а последней идёт нить Ultrapak 22.11 N/mm^2.

Заключение: Плетёные ретракционные нити обладают более высокой прочностью на растяжение по сравнению с нитями Ультрапак # 00, изготовленными по технологии вязания.

Ключевые слова

ретракция десны, физические свойства, ретракционные агенты