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Farklı çaplarda ki polipropilen sütürlerde düğüm güvenliği için gereken minimum düğüm atma sayısının belirlenmesi: in-vitro çalışma

Determining the minimum required number of throws for knot security in different diameters of polypropylene sutures: an in-vitro study

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ÖZ

GİRİŞ: *Sütür materyalin tipi, düğüm sayısı, düğüm teknikleri ve cerrahın deneyimi, düğüm güvenliği konusunda önemli bir etkiye sahiptir. Bu çalışmanın temel amacı, farklı boyutlardaki polipropilen sütürlerde güvenli bir düğüm oluşturmak için gerekli minimum atım sayısını belirlemektir.*

GEREÇ VE YÖNTEM: *Çalışma için iki grup oluşturuldu; Grup I: işlem görmemiş polipropilen sütürler ve Grup II: Yağ emdirilmiş polipropilen sütürler. Toplamda 144 adet polipropilen sütür kullanıldı. Sütür kopması ölçümü için kullanılan çekme kuvveti 0,5 mm / sn idi. Kırılma ya da çözülme nedeniyle başarısız olan düğümler kaydedildi.*

BULGULAR: *Düğüm atma sayısı arttıkça tüm polipropilen sütür gruplarında kaymadan dolayı çözünme oranı azalmış olmasına rağmen, yağ emdirilmiş grupta çözünme oranları daha yüksek bulunmuştur. Aynı sayıda düğüm atma ile yapılmış, ancak farklı büyüklükte ipliklerle (2 / 0,3 / 0,4 / 0,5 / 0) düğümlenmeye veya kırılmasına yönelik gerekli ortanca kuvvet seviyelerinde istatistiksel olarak anlamlı bir fark yoktu. Düğüm kayması veya kopması için gerekli olan ortanca kuvvet seviyelerini analiz etmek için kullanılan Bonferroni ayarlama testine göre, herhangi bir Grup I'de veya yağlı sütür ile herhangi bir Grup II'de 3, 4 veya 5 kez bağlanan düğümler arasında istatistiksel olarak anlamlı bir fark yoktu.*

SONUÇ: *Bu çalışmanın sonuçları, in-vitro ortamda düğüm güvenliğini sağlamak için polipropilen iplikte aynı yönde 3 düğüm atmanın yeterli olduğunu göstermektedir. Ek olarak, polipropilen sütürlerin yağlanması düğüm güvenliğini tehlikeye atmaz.*

Anahtar Kelimeler: *sütür, düğüm atma, polipropilen, düğüm güvenliği*

ABSTRACT

BACKGROUND: *The type of suture material, the number of knots, knotting techniques and the surgeon's experience all have an important impact on knot safety. The primary aim of the present study was to determine the minimum number of throws necessary to create a secure knot in polypropylene sutures of different sizes.*

MATERIALS AND METHODS: *Two groups were formed; Group I: Naive polypropylene sutures and Group II: Oily impregnated polypropylene sutures. In total, 144 pieces of polypropylene suture were used. The pulling force used for suture break measurement was 0.5 mm/sec. Knots that failed due to breaking or untying were recorded.*

RESULTS: *As the number of throws increased, the rate of slipped knots decreased in all polypropylene suture groups, although dissolution rates were higher in the oil impregnated group. There was no statistically significant difference in the median force levels required for untying or breaking knots made with the same number of throws but with different sizes of thread (2/0,3/0,4/0,5/0). According to the Bonferroni adjustment test, used to analyze the median force levels required for knot slippage or breaking, there was no statistically significant difference between knots tied 3, 4 or 5 times in either any Group I, or in any Group II with oily sutures.*

CONCLUSION: *Results of the present study indicate that 3 throws of polypropylene sutures in the same direction are sufficient for knot security in an in-vitro environment. Additionally, impregnation of the polypropylene sutures with oil does not compromise knot security.*

Keywords: *suture, throw, polypropylene, knot security*

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INTRODUCTION

The type of suture material, the number of knots, knotting techniques and the surgeon's experience all play an important role in knot safety. In most surgical procedures, tying knots with suture material is an essential component of maintaining tissue apposition. Security of a knot is crucial to holding tissues together until they have healed, and a secure knot is defined as one that does not untie or slip open before the suture line breaks [1]. Tensile breaking strength is commonly defined as the force that a suture can withstand before breaking [2]. The type of suture and the type of knot inevitably impact this knot security.

The primary aim of the present study was to determine the minimum number of throws necessary to create a secure knot in polypropylene sutures of different sizes (2/0, 3/0, 4/0, 5/0), independent of the surgeon's experience or the suture patterns used. The second purpose was to determine whether the use of oil impregnated polypropylene sutures would make a difference to the number of throws required.

MATERIALS AND METHODS

For the purposes of this study, a secure knot was defined as a knot that failed by breaking or untying. The suture materials tested were polypropylene sutures of different sizes (2/0, 3/0, 4/0 and 5/0) (Prolentm Ethicon), two groups were formed: Group I consisted of Naive polypropylene sutures and Group II of Oily impregnated polypropylene sutures. A tensile tester (Zwick/ RoellR - Germany) was used to measure their strength: a hook was placed on the pull arms of the device **(Figure 1)** and the sutures in each group were passed through these hooks and tied with 3, 4, or 5 throws to measure the breaking or untying forces 6 times **(Figure 2).**

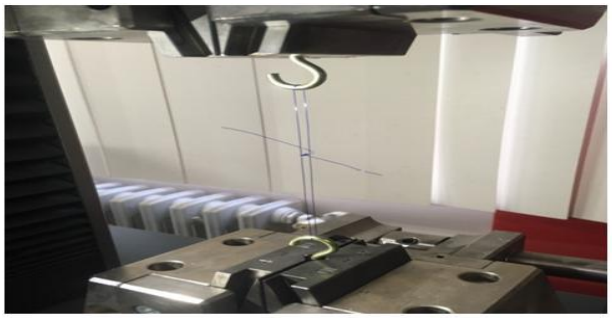

Figure 1. Tensile tester (Zwick/ RoellR - Germany) A hook is placed on the pull arms of the device.

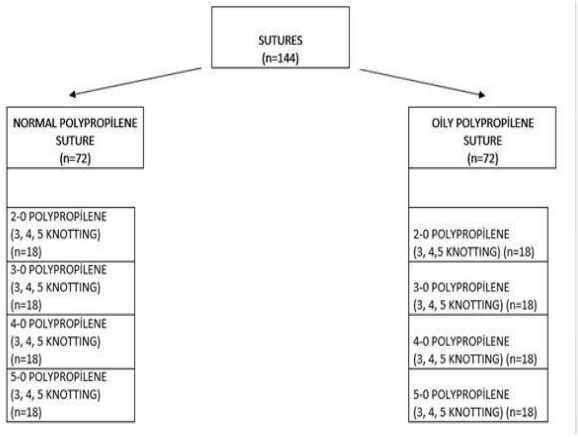

Figure 2. Schema showing the prolene sutures used

In total, 144 pieces of polypropylene suture were used. All knots were performed by the same surgeon, who used powder-free gloves. Knots were performed one by one with clockwise throws. The suture ends (tails) were cut to 5 mm length (measured with a ruler before cutting). The applied forces were recorded in Newtons and the pull for breaking force measurement was 0.5 mm/sec. Knots that failed by breaking or untying were recorded.

Statistical Analysis

Data analysis was performed using IBM SPSS Statistics version 17.0 software (IBM Corporation, Armonk, NY, USA). The normality of the distribution of continuous variables was determined by the Kolmogorov Smirnov test and the Levene test was used for the evaluation of homogeneity of variances. While continuous variables were expressed as a median (interquartile range), categorical data was measured in the number of cases and as percentages. Measurements of the differences in strength between normal and oily sutures were compared using the Mann Whitney U test; while the Kruskal Wallis test was applied for comparisons between more than two independent groups. When the p value from this test was statistically significant, Conover's multiple comparison test was used to determine which group differed from which others. Categorical data was analyzed by Fisher's exact test. A p value less than 0.05 was considered as statistically significant. However, in all possible multiple comparisons, the Bonferroni Adjustment test was applied to avoid Type I errors. According to

the Bonferroni adjustment test, a p value less than 0.00625 was considered as statistically significant.

RESULTS

In all polypropylene suture groups, the untying rates decreased as the number of throws increased, with dissolution rates higher in the oiled group than in the normal group **(Figure 3).**

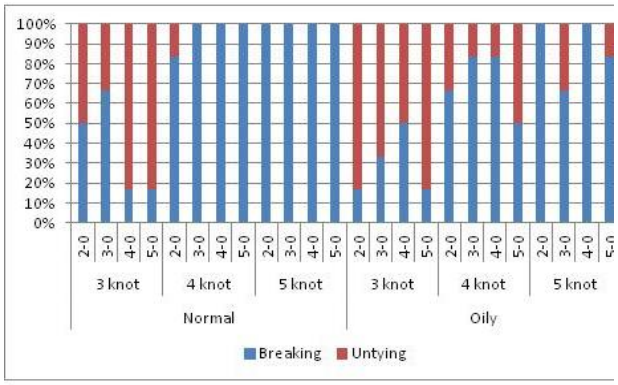

Figure 3. The untying and dissolution rates in the groups

The median force value required for the untying or breaking of sutures in Group I and Group II are shown in **Figure 4.**

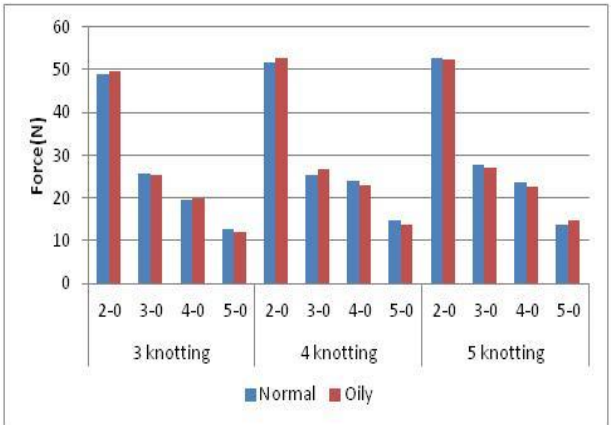

Figure 4. The median force needed for untying or suture breaks in groups

There was no statistically significant difference in the median force needed in GroupsI and II for untying or knot breaking, when the same number of throws was used. (3 throws: p=0.485; 4 throws: p=0.937; 5 throws: p=0.699) **(Table 1)**

Table 1. The median breaking force levels required for untying or knot breaking in the 2/0, 3/0, 4/0, and 5/0 polypropylene sections of Groups I and II, after knotting 3/4/5 times.

	3 knotting	4 knotting	5 knotting	p-value †
2-0				
Normal	**48.97 (7.18)**	**51.78 (4.54)**	**52.68 (6.26)**	**0.135**
Oily	**49.77 (4.72)**	**52.58 (7.22)**	**52.33 (2.79)**	**0.271**
p-value ‡	**0.485**	**0.937**	**0.699**	
3-0				
Normal	**25.86 (5.84)**	**25.18 (3.29)**	**27.84 (4.40)**	**0.504**
Oily	**25.39 (1.33)**	**26.86 (1.46)**	**27.13 (2.83)**	**0.114**
p-value ‡	**0.818**	**0.589**	**1.000**	
4-0				
Normal	**19.59 (1.50)**	**23.95 (4.10)**	**23.69 (5.33)**	**0.035**
Oily	**19.96 (1.93)**	**22.94 (2.66)**	**22.56 (2.78)**	**0.076**
p-value ‡	**0.394**	**0.394**	**0.818**	
5-0				
Normal	**12.66 (2.56)**	**14.60 (0.79)**	**13.64 (1.45)**	**0.016**
Oily	**12.10 (1.52)**	**13.84 (2.30)**	**14.65 (1.30)**	**0.020**
p-value ‡	**0.394**	**0.485**	**0.093**	

In group I, when using size 2/0 polypropylene sutures, there was no statistically significant difference in the median force levels required for dissolution or knot breaking when knots were tied 3, 4 or 5 times(p=0.135). Likewise, with size 2/0 polypropylene sutures in Group II, no statistically significant difference was seen for different numbers of knots (p=0.271).

Similarly, for size 3/0 polypropylene sutures there was no statistically significant difference between the median breaking force levels of Group I and II (3 throws: p=0.818; 4 throws: p=0.589; 5 throws; p=1.0).

In group I, using3/0 polypropylene sutures, there was no statistically significant difference in the median breaking force between knots tied 3, 4 or 5 times(p=0.504); with similar non-significant results for Group II size 3/0 polypropylene sutures (p=0.114).

When size 4/0 polypropylene sutures were used, there was no statistically significant difference between median force levels in Group I and Group II for the same number of knots. (3 throws: p=0.394; 4 throws: p=0.394; 5 throws: p=0.818) (Table 1).

In group I with 4/0 polypropylene sutures, the Bonferroni adjustment test indicated no statistically significant difference in median breaking force levels whether knots were tied 3, 4 or 5 times (p=0.035). Similar results were found in Group II 4/0 sutures (p=0.076).

With 5/0 polypropylene sutures, there was again no statistically significant difference between Group I and Group II regarding the number of knots thrown(3 throws: p=0.394; 4 throws: p=0.485; 5 throws: p=0.093).

In group I using 5/0 polypropylene sutures, the Bonferroni adjustment test revealed no statistically significant difference in the median breaking force between knots tied 3, 4 or 5 times (p=0.016). Likewise, with 5/0 sutures in Group II, similar non-significant results were found (p=0.020).

DISCUSSION

Knot security is influenced by a variety of factors including the number of throws, the type of suture and the type of pattern to be used [3]. In contrast to previous studies, where a minimum of 4 throws were recommended for knot security, the results of the present study indicate that 3 throws are sufficient to achieve a secure knot [4,5]. Furthermore, the findings of the present study are supported by a study conducted by Danielle M. et al. [6], which pointed out that a minimum of 3 throws is needed for knot security. We found that knots broke before the suture was untied; a circumstance that was also mentioned in the study by Danielle et al. [6].When knot failure or suture breakage occurred, it was immediately adjacent to the knot itself in 85%of cases [6].

An important surgical principle is to leave the minimum amount of foreign suture material in the tissue, while still maintaining the integrity of the suture and the security of the knot [3], as suture materials contribute to local inflammation and bacterial colonization. [6,7] The greatest inflammation and tissue reaction occurs in the knot component of the suture line because the highest density of foreign material is located here. [7] Therefore, identifying the minimum number of throws required to produce a secure knot has important implications. Our study shows that it may be possible to tie a secure knot with only 3 throws when using polypropylene material.

Another important finding of the present study is that the number of throws required for a secure knot does not significantly change when using oil impregnated polypropylene sutures. However in a recent study showed that 4 throws were required for knot security, whereas 5 throws were required for sliding knots [8], in our study we found that sliding sutures were not required more throws than non-sliding sutures.

In a previous study by Apt et al. [9], it was reported that oil did not compromise the knot security or cause an unusual postoperative reaction; they asserted the effectiveness of oiling synthetic absorbable sutures at the time of surgery. Our study also supports this view for non-absorbable sutures.

The present study has some limitations. First, it is an in-vitro study. Secondly, factors affecting suture strength and knot security, including intra-corporeal effects such as ischemia, inflammation and overall tissue health, could not be evaluated. More in-vivo studies are required for a definitive answer.

In conclusion, the results of the present study indicate that 3 throws of polypropylene sutures, in the same direction, are sufficient for knot security in an in-vitro environment. Additionally, the impregnation of polypropylene sutures with oil does not compromise knot security.

REFERENCES

1. Burkhart SS, Wirth MA, Simonich M, Salem D, Lanctot D, Athanasiou K. Knot security in simple sliding knots and its relationship to rotator cuff repair: how secure must the knot be? Arthroscopy 2000; 16: 202–207.
2. Welch Fossum T. Biomaterials, suturing, and hemostasis, in. Small animal surgery (ed 3). St. Louis, MO, Mosby Inc., 2007, pp 57–78.
3. Campbell EJ, Bailey JV. Mechanical properties of suture materials in vitro and after in vivo implantation in horses. Vet Surg 1992; 21: 355–36.
4. Marturello DM, McFadden MS, Bennett A, Ragetly GR, Horn G. Knot Security and Tensile Strength of Suture Materials. Veterinary Surgery 2014; 43, 73–79.

5. Schaaf O, Glyde M, Day RE. In vitro comparison of secure Aberdeen and square knots with plasma and fat coated polydioxanone. Vet Surg 2010; 39: 553–560.
6. Campbell EJ, Bailey JV. Mechanical properties of suture materials in vitro and after in vivo implantation in horses. Vet Surg 1992; 21: 355–361.
7. Rosin E, Robinson G. Knot security of suture materials. Vet Surg 1989;18: 269–273.
8. Silver E, Wu R, Grady J, Song L. Knot Security-How is it Affected by Suture Technique, Material, Size, and Number of Throws? J Oral Maxillofac Surg 2016; 74(7): 1304-12.
9. Apt L, Henrick A. "Tissue-drag" with polyglycolic acid (Dexon) and polyglactin 910 (Vicryl) sutures in strabismus surgery. J Pediatr Ophthalmol. 1976; 13(6): 360-364.