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In Vitro Biomechanical Study on the "Figure-of-Eight" and Kessler Sutures in Swine Flexor Tendons*

Estudo biomecânico in vitro das suturas em "oito" e de Kessler de tendões flexores de porcos

Diogo Thomaz Kawachi[1] Francisco Simões Deienno[1] Denis Varanda[1] Andrea Christina Cortopassi[1] Trajano Sardenberg[1]

[1] Departament of Surgery and Orthopedics, Faculdade de Medicina de Botucatu, Universidade Estadual Paulista (Unesp), Botucatu, SP, Brazil

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Address for correspondence Diogo Thomaz Kawachi, Departamento de Cirurgia e Ortopedia, Faculdade de Medicina de Botucatu, Universidade Estadual Paulista (Unesp), Avenida Professor Mário Rubens Guimarães Montenegro s/n, Campus de Botucatu, Botucatu, SP, 18618687, Brazil (e-mail: thedinhoz@yahoo.com.br).

Abstract

Objective To evaluate the biomechanical properties of the "figure-of-eight" and Kessler suture techniques for tendons.

Methods Flexor tendons of porcine fingers were divided into two groups with triple central "figure of eight" sutures (six passages) and Kessler sutures (two passages) associated with simple and continuous peripheral sutures, and submitted to continuous longitudinal mechanical tests, to obtain the mechanical properties of maximum load and energy at maximum load.

Results The mean maximum load and energy at maximum load in the "figure-of-8" suture were of 63.4 N and 217.3 N.mm respectively; in the Kessler suture, the values were of 34.19 N and 100.9 N.mm respectively. The statistical analysis indicated that the "figure-of-eight" suture is mechanically superior to the Kessler technique.

Conclusion Under the conditions of this experiment and in the flexor tendon of porcine fingers, the triple "figure-of-eight" suture (six passages) is more resistant than the Kessler suture (two passages). The "figure-of-eight" suture with six passages enables active movement in the immediate rehabilitation of the flexor tendon repair of the finger, with little risk of rupture or suture spacing.

Keywords
- orthopedic procedures
- biomechanical phenomenon
- tendon injuries
- finger injuries
- suture techniques

Resumo

Objetivo Avaliar as propriedades biomecânicas dos pontos de sutura tendinosa em "oito" e de Kessler.

Métodos Tendões flexores dos dedos de membros superiores de porcos foram divididos em dois grupos com suturas triplas centrais em "oito" (seis passagens) e de Kessler (duas passagens) associadas a suturas periféricas continuas simples, e submetidos a ensaios mecânicos longitudinais contínuos, obtendo-se as propriedades mecânicas de carga máxima e de energia na carga máxima.

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Palavras-chave
- procedimentos ortopédicos
- fenômeno biomecânico
- traumatismos dos tendões
- traumatismos dos dedos
- técnicas de sutura

Resultados As médias da carga máxima e da energia na carga máxima na sutura em "8" foram de 63,4 N e 217,3 Nmm, respectivamente; na sutura de Kessler, os valores foram de 34,19 N e 100,9 Nmm, respectivamente. A análise estatística indicou que o ponto em "oito" é superior mecanicamente ao ponto de Kessler.

Conclusões Nas condições deste experimento e no tendão flexor de dedo de membro superior de porcos, o triplo ponto em "oito" (seis passagens) é mais resistente do que o ponto de Kessler (duas passagens). O ponto em "oito" com seis passagens permite movimentação ativa na reabilitação imediata de reparo de tendão flexor de dedo de membro superior com pouco risco de ruptura ou espaçamento na sutura.

Introduction

The need for active postoperative movement of the flexor tendon repairs of the fingers in zones II, III, IV and V, to prevent adhesions and obtain proper range of motion, requires suture stitches with high mechanical resistance.[1,2] Among the various qualifications for optimal repair, such as number of passages, thread qualities, suture volume, among others, ease of performance with minimal surgical trauma is fundamental.[2] The six-passage "figure-of-eight" suture is easy to perform, it can be made with various types of surgical threads, has great mechanical resistance for active postoperative movement, and its efficiency has been proven in clinical and biomechanical studies.[3–7] Although there are no studies on the preference of Brazilian surgeons for the suture technique used in the flexor tendons of the fingers, it is believed, by empirical observation, that the Kessler suture is one of the most widely used. The classic method to study the mechanical properties of intact or sutured tendons is to subject the specimen to strain deformation at constant speed.[8] The experimental model to biomechanically test the immediate suture of flexor tendons using swine specimens, by mechanical test of longitudinal traction under constant traction speed, finds reference in the literature.[9–11] The objective of the present study was to biomechanically evaluate, through longitudinal tensile tests at constant speed, the deformation by tension of the "figure-of-eight" and Kessler sutures in swine flexor tendons.

Materials and Methods

The upper limbs of 18 pigs were disarticulated at the elbow, packed in plastic bags and kept in a freezer at -20 degrees Celsius. On the day of the experiments, the anatomical parts were thawed at room temperature, and the deep flexor tendons of the fingers were dissected and isolated. The tendons of the right upper limbs were divided into two groups: group F8 (3 "figure-of-8" stitches) and group K (Kessler suture). The tendons of both groups were sectioned in the central region with a scalpel blade number 15 and submitted to sutures: the F8 group with 3 "figure-of-8" stitches with polypropylene monofilament yarn 3–0 (Prolene, Ethicon, São José dos Campos, SP, Brazil), and, in group K, Kessler suture with the same surgical thread; in both groups there were continuous peripheral sutures with polypropylene monofilament thread 4–0 (Prolene) (►**Figure 1**). After suturing, the tendons were fixed in aluminum sinusoidal metal claws, compressed by screws with a distance of 20 mm from the suture region in the central part. The claws were mounted axially in a universal mechanical testing machine with a 1,000-N load cell and application

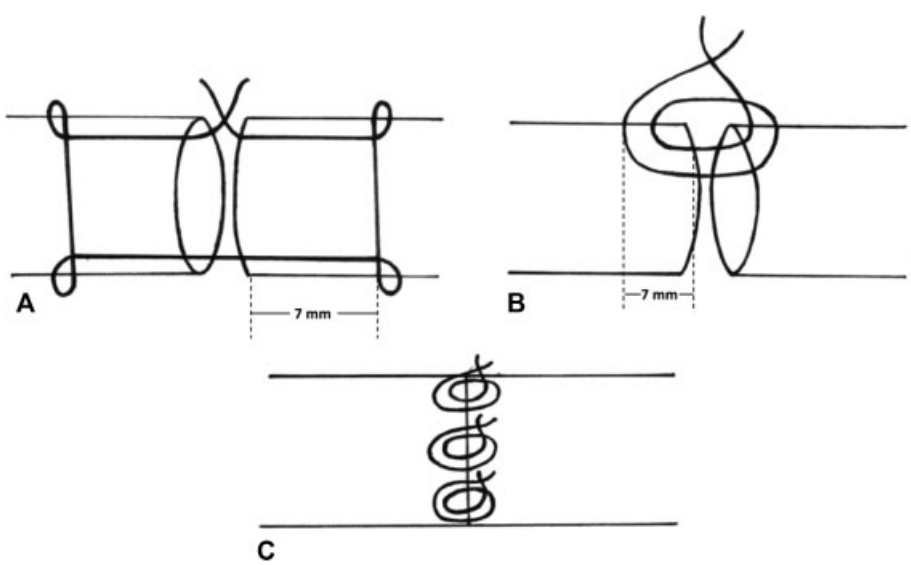

Fig. 1 Schematic representation of tendon repair techniques used in the K (**A**) and F8 (**B** and **C**) groups.

Table 1 Means, standard deviations, maximum and minimum values and statistical analyses of the mechanical properties of maximum load (N) and energy at maximum load (N.mm) in the experimental groups

Groups	Maximum load	Energy at maximum load
K ($n = 8$)	34.19 ± 11.4; maximum: 58.55; minimum: 18.29	100.9 ± 52.48; maximum: 206.5; minimum 34.61
F8 ($n = 10$)	63.40 ± 20.40; maximum: 86.04; minimum: 23.17	217.3 ± 93.67; maximum: 365.7; minimum 33.39
p-value	0.0024*	0.0064*

Note: $^*p < 0.5$.

speed of 30 mm/min (EMIC DL 10000, Instron, São José dos Pinhais, PR, Brasil). After the test, the computer coupled to the equipment provided the mechanical properties of maximum load (N) and energy at maximum load (N.mm).

The statistical analyses of the results were performed using the Student *t* test, with values of $p < 0{,}5$ considered significant.

Results

In groups F8 and K, ruptures always occurred in the suture area, and it was not possible to determine the sequence of the ruptured stitches, since there was no filming of the mechanical tests. ►**Table 1** presents the results of the mechanical properties in both groups, which indicate higher values in the F8 group ($p < 0{,}5$).

Discussion

The present study demonstrated that the triple "figure-of-eight" suture (six passages) presents values for the mechanical properties of maximum load and energy at maximum load that are statistically higher than those of the Kessler suture, which is in line with the results of the study by Al-Qattan and Al-Turaiki.[3] The maximum load value of a flexor tendon suture of a finger to enable active movement without risk of rupture or suture spacing is at least 40 N, a value higher than that observed in the K group (34.19 N), and lower than that of the F8 group (63.4 N), indicating the safety of the triple "figure-of-eight" suture.[12]

Knowledge of the maximum load mechanical property is fundamental in assessing the strength of a given tendon suture, and is one of the most used parameters in biomechanical studies.[2,8,12] On the other hand, the clinical importance of the energy property at full load is not fully understood.[2] The energy at maximum load represents the impact absorption capacity of a given material; a larger value of this property could, in theory, mitigate the impact of the suture on the pulley system of the osteofibrous canal in the anterior region of the fingers during articular movement, facilitating tendon slippage and hindering the formation of scar adhesions.

The present study has methodological limitations: no mensuration of the necessary load to produce suture spacing that can, theoretically, impair healing; the use of continuous and longitudinal mechanical testing instead of cyclic and curvilinear tests; and, finally, the use of isolated swine tendons instead of human hand or finger tendons. However, within these limitations inherent to the methods used, one should keep in mind that the central basis of the present study was the comparison of the immediate mechanical properties of the "figure-of-eight" and Kessler sutures, both performed and tested under the same experimental conditions and, therefore, the results obtained have scientific validity.

Conclusions

Under the conditions of this experiment and considering the use of flexor tendons of porcine fingers, the Al-Qattan and Al-Turaik[3] triple "figure-of-eight" suture (six passages)[3] is more resistant than the Kessler suture (two passages). The "figure-of-eight" suture with six passages enables active movement in the immediate rehabilitation of flexor tendon repair in fingers, with little risk of rupture or spacing of the suture.

Conflict of Interests
The authors have none to declare.

References

1 Bindra RR. Basic pathology of the hand, and forearm: tendon and ligament. In: Berger RA, Weiss AP, editors. Hand surgery. Philadelphia: Lippincott Williams & Wilkins; 2003:23–35
2 Pérez-Barquero JÁ, Sabaté EF, Sánchez-Alepuz E. Concepto biomecánicos de las suturas tendinosas. Rev Iberam Cir Mano 2018; 46:143–149
3 Al-Qattan MM, Al-Turaiki TM. Flexor tendon repair in zone 2 using a six-strand 'figure of eight' suture. J Hand Surg Eur Vol 2009;34 (03):322–328
4 Al-Qattan MM. Finger zone II flexor tendon repair in children (5-10 years of age) using three 'figure of eight' sutures followed by immediate active mobilization. J Hand Surg Eur Vol 2011;36(04):291–296
5 Al-Qattan MM. Zone 2 lacerations of both flexor tendons of all fingers in the same patient. J Hand Surg Eur Vol 2011;36(03):205–209
6 Agrawal AK, Mat Jais IS, Chew EM, Yam AK, Tay SC. Biomechanical investigation of 'figure of 8' flexor tendon repair techniques. J Hand Surg Eur Vol 2016;41(08):815–821
7 Al-Thunayan TA, Al-Zahrani MT, Hakeem AA, Al-Zahrani FM, Al-Qattan MM. A biomechanical study of pediatric flexor profundus tendon repair. Comparing the tensile strengths of 3 suture techniques. Saudi Med J 2016;37(09):957–962
8 Nordin M, Lorenz T, Campelo M. Biomecânica de tendões e ligamentos. In: Nordin M, Frankel VH, editors. Biomecânica básica do sistema musculoesquelético. Rio de Janeiro: Guanabara Koogan; 2003:86–107
9 Viinikainen A, Göransson H, Huovinen K, Kellomäki M, Rokkanen P. A comparative analysis of the biomechanical behaviour of five flexor tendon core sutures. J Hand Surg [Br] 2004;29(06):536–543
10 Xie RG, Tang JB. Investigation of locking configurations for tendon repair. J Hand Surg Am 2005;30(03):461–465
11 Cao Y, Zhu B, Xie RG, Tang JB. Influence of core suture purchase length on strength of four-strand tendon repairs. J Hand Surg Am 2006;31(01):107–112
12 Tang JB, Xie RG. Biomechanics of core and peripheral tendon repairs. In: Tang JB, Amadio PC, Guimberteau JC, Chang J, editors. Tendon surgery of the hand. Philadenphia: Saunders Elsevier; 2012:35–48