Hindawi Publishing Corporation
ISRN Plastic Surgery
Volume 2014, Article ID 687128, 4 pages
http://dx.doi.org/10.1155/2014/687128

Research Article

Flexor Tendon Injuries in the Hand: A UK Survey of Repair Techniques and Suture Materials—Are We Following the Evidence?

W. B. J. Rudge[1] and M. James[2]

[1] *Frimley Park Hospital NHS Foundation Trust, Portsmouth Road, Frimley, Surrey GU16 7UJ, UK*
[2] *Guy's and St Thomas' NHS Foundation Trust, Westminster Bridge Road, London SE1 7EH, UK*

Correspondence should be addressed to W. B. J. Rudge; willrudge@hotmail.com

Received 7 February 2014; Accepted 27 February 2014; Published 18 March 2014

Academic Editors: J. W. Park, E. Raposio, and F. Siemers

Introduction. Injuries to the hand are common, and poor functional outcomes can have significant long-term consequences affecting both work and social activities. Good outcomes following flexor tendon lacerations in the hand are dependent on a sound surgical repair allowing early active mobilisation. *Materials and Methods*. We reviewed the literature regarding the choice of suture material and repair technique. We then carried out a nationwide postal survey of plastic surgery hand units to assess the level of compliance with the evidence. *Results*. Fifty-four units were surveyed. The response rate was 72%, with the most popular core suture being Prolene (64%) and the most popular technique being the Kessler repair (36%). *Discussion*. Current evidence advocates a multistrand repair using Ethibond. We found that the majority of units are not following the evidence. We suggest the use of evidence-based departmental guidelines to improve the practice and outcomes following these common injuries.

1. Introduction

Injuries to the hand are common, accounting for around one-fifth of all presentations to the emergency department in most hospitals and costing over £100,000,000 per year in the United Kingdom to treat [1]. Of these patients around 1-2% have tendon lacerations [2], more commonly on the flexor aspect. Strickland [3] described the characteristics of an ideal primary flexor tendon repair:

(i) easily placed in tendon;

(ii) secure knots;

(iii) smooth junctions;

(iv) minimal gapping;

(v) minimal interference with tendon vascularity;

(vi) sufficient strength throughout healing to permit application of early motion stress.

Early active mobilisation has been shown to be important in terms of preventing the formation of adhesions [4], stimulating tendon healing [5], and improving functional outcome [6, 7]. Immediately after a tendon repair, the tendon itself will contribute nothing to the strength of the repair, which is therefore entirely dependent on the suture material and the technique used, as well as meticulous surgical technique and careful tissue handling. Suture material and technique are thus crucial to the survival of the repair. We have examined the evidence related to different suture materials and the different techniques for tendon repair and compared this with current practice in plastic surgery hand units within the United Kingdom and the Republic of Ireland.

2. Current Evidence

2.1. Suture. The ideal core suture material should have high tensile strength, be inextensible, cause no tissue reaction, and be easy to handle and knot [8]. Stainless steel fulfils the first 3 of these criteria and was historically the recommended choice

[9]. However, this has now fallen out of favour due to poor handling characteristics, problems with kinking, and bulky knot formation. The sutures used most commonly in the UK are Prolene (Ethicon, Edinburgh, UK), a monofilament polypropylene suture; Ethibond (Ethicon), braided polyethylene terephthalate coated with polybutilate; and Ticron (Tyco Healthcare, Gosport, UK), braided polyester coated with silicon. Also gaining popularity is Fiberwire (Arthrex, Naples, FL), a multistranded long chain polyethylene core with a polyester braided jacket. These have all been evaluated in purely material terms and also their biomechanical properties when used in tendon repairs.

Despite its poor handling stainless steel has been shown to be stiffer and have a higher tensile strength than its competitors [8, 10], Fiberwire has similar biomechanical properties, but improved handling [10]. However, there are still concerns with regard to the knotting of Fiberwire, and the multiple knots required for a secure hold result in a bulky repair [11]. Ethibond is next stiffest, with increased stiffness and reduced gapping relative to Prolene [10, 12]. In addition Ethibond is stiffer than Nylon [13], PDS, Maxon, Dexon, and Vicryl and does not show significant deterioration in its mechanical properties following *in vivo* incubation after 6 weeks [12]. Ethibond therefore has a good balance of mechanical properties and handling/knotting characteristics.

Increasing the size of the core suture increases the strength of the repair [14]. Using a 2–0 core suture significantly increases the maximum tensile strength of the repair when compared with 3–0 or 4–0 sutures but also increases the resistance to gliding of the tendon, measured as work of flexion [15]. The same study showed no significant difference between 3–0 and 4–0 sutures for either tensile strength or work of flexion.

2.2. Repair Technique. There have been many different techniques described for the repair of digital flexor tendons, including the Kessler repair [16], which was modified in 1979 [17], Strickland repair [3], and Savage repair [18], all of which are in common usage. Many studies have demonstrated that the strength of a flexor tendon repair is roughly proportional to the number of suture strands crossing the site of the repair [19–21]. However, increasing the number of strands may lead to a bulkier repair [22] and increased work of flexion [23]. Four strand repairs are therefore gaining in popularity, with a reasonable balance between strength and size of repair. The 4-Strand Cruciate repair shows good biomechanical properties when compared with a variety of other options [24–26]. It has been shown that there is no increase in operative time for this repair, and it is no more technically challenging to a trainee surgeon [27].

3. Method

We sent a postal survey questionnaire to the hand unit of all plastic surgery departments within the UK and Ireland (from a list taken from the website of the British Association of Plastic, Reconstructive and Aesthetic Surgeons), excluding children's hospitals and those performing elective surgery only. We asked if there was a departmental protocol or guidelines for the repair of zone II flexor tendon lacerations, and if so what was the choice of repair technique, core suture, and peripheral suture. We also asked for the personal preference of the lead consultant of the hand unit in each of these same categories.

Table 1: Choice of repair technique.

	Strand number	Number	Percentage
Kessler	2	14/39	36%
Modified Kessler	4	11/39	28%
Strickland	4	7/39	18%
Modified Savage	6	5/39	13%
4-Strand Cruciate	4	2/39	5%

Table 2: Choice of core suture.

	Number	Percentage
Prolene	25/39	64%
Ethibond	10/39	26%
Ticron	3/39	8%
PDS	1/39	3%
3–0	32/39	82%
4–0	7/39	18%

4. Results

From the 54 units surveyed we had 39 replies—a response rate of 72%. Of these 39, 18 (46%) had departmental protocols. The protocols were identical to the personal preference of the lead consultant in all except 2 departments, showing that for the purposes of this study the personal preference of the lead consultant could be used as a standard to allow for comparison between those departments with guidelines and those without.

The results for repair techniques are shown in Table 1. The Kessler repair was by far the most commonly used, being the technique of choice in 25 units (64%). Fourteen units (36%) used a standard Kessler repair (2 strands), and 11 units (28%) used a modified Kessler repair (4 or more strands). The other techniques used were the Strickland repair (7 units, 18%), the Modified Savage repair (5 units, 13%), and the 4-Strand Cruciate repair (2 units, 5%).

The results for core sutures are shown in Table 2. The most commonly used material for the core suture was Prolene, used in 25 units (64%). This was followed by Ethibond (10 units, 26%) and Ticron (3 units, 8%), the two braided polyester sutures. PDS was used in 1 unit (3%). Thirty-two units (82%) used 3–0 core sutures, with the remaining 7 units (18%) choosing a 4–0 core suture.

The results for the preipheral suture are shown in Table 3. By far the most commonly used material for the peripheral suture was Prolene, used in 32 units (82%), with the remaining 7 units (18%) using Nylon. Twenty-eight units (72%) used 6–0 peripheral sutures, with the remaining 11 units (28%) choosing a 5–0 peripheral suture.

Table 3: Choice of peripheral suture.

	Number	Percentage
Prolene	32/39	82%
Nylon	7/39	18%
6–0	28/39	72%
5–0	11/39	28%

5. Discussion

Flexor tendon injuries are common, and a good functional outcome relies on a strong low friction repair to allow early mobilisation, without compromising the vascularity of the tendon and without the formation of adhesions. The choice of suture material and repair technique is a complex one and involves a balance between tensile strength, ease of handling and knotting, technical difficulty, and work of flexion following repair.

There is no single core suture material which meets perfectly all of the requirements as described by Trail [8]. However, there is an increasing weight of evidence to support Ethibond as the best compromise. In our study only 26% of units were using Ethibond. The majority (64%) were using Prolene, which is biomechanically inferior to Ethibond [10, 12].

The size of the core suture has an impact on tensile strength and work of flexion of the repair, with 2–0 sutures being stronger—but causing more friction—than 3–0 or 4–0 sutures [15]. The balance between tensile strength and work of flexion therefore remains a choice for the surgeon. In our study all units were using either 3–0 or 4–0 sutures, which show no statistically significant difference in tensile strength or work of flexion.

There are many different options for the repair technique, but it is now clear that a two-strand repair is biomechanically inferior to a repair with 4 or more strands. Despite this we found that a two strand Kessler repair remains the most popular choice, being the preferred technique in 36% of respondents. These findings are similar to those of an earlier survey [28].

6. Conclusions

The majority of studies comparing strengths of tendon repairs are based on cadaveric, nonhuman, and purely biomechanical data. There is a need for large scale randomised control trials to evaluate clinical outcomes for different suture choices and repair techniques. Our study shows that there is a wide range of suture materials and repair techniques in use. Even despite the limitations of current evidence, it would appear that many units are carrying out tendon repairs based on historical preferences rather than making evidence-based choices. There needs to be improved awareness of the evidence, and we would suggest that departmental guidelines should be drawn up or updated based on current evidence in order to encourage best practice.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

References

[1] J. J. Dias and M. Garcia-Elias, "Hand injury costs," *Injury*, vol. 37, no. 11, pp. 1071–1077, 2006.

[2] W. H. Frazier, M. Miller, R. S. Fox, D. Brand, and F. Finseth, "Hand injuries: incidence and epidemiology in an emergency service," *Journal of the American College of Emergency Physicians*, vol. 7, no. 7, pp. 265–268, 1978.

[3] J. W. Strickland, "Flexor tendon injuries: I&II," *Journal of the American Academy of Orthopaedic Surgeons*, vol. 3, no. 1, pp. 44–62, 1995.

[4] M. Aoki, H. Kubota, D. L. Pruitt, and P. R. Manske, "Biomechanical and histologic characteristics of canine flexor tendon repair using early postoperative mobilization," *Journal of Hand Surgery*, vol. 22, no. 1, pp. 107–114, 1997.

[5] H. Kubota, P. R. Manske, M. Aoki, D. L. Pruitt, and B. J. Larson, "Effect of motion and tension on injured flexor tendons in chickens," *Journal of Hand Surgery*, vol. 21, no. 3, pp. 456–463, 1996.

[6] L. C. Bainbridge, C. Robertson, D. Gillies, and D. Elliot, "A comparison of post-operative mobilization of flexor tendon repairs with "passive flexion-active extension" and "controlled active motion" techniques," *Journal of Hand Surgery*, vol. 19, no. 4, pp. 517–521, 1994.

[7] H. Lee, "Double loop locking suture: a technique of tendon repair for early active mobilization. Part II. Clinical experience," *Journal of Hand Surgery*, vol. 15, no. 6, pp. 953–958, 1990.

[8] I. A. Trail, E. S. Powell, and J. Noble, "An evaluation of suture materials used in tendon surgery," *Journal of Hand Surgery*, vol. 14, no. 4, pp. 422–427, 1989.

[9] R. G. Pulvertaft, "Suture materials and tendon junctures," *The American Journal of Surgery*, vol. 109, no. 3, pp. 346–352, 1965.

[10] T. M. Lawrence and T. R. C. Davis, "A biomechanical analysis of suture materials and their influence on a four-strand flexor tendon repair," *Journal of Hand Surgery*, vol. 30, no. 4, pp. 836–841, 2005.

[11] T. Waitayawinyu, P. A. Martineau, S. Luria, D. P. Hanel, and T. E. Trumble, "Comparative biomechanic study of flexor tendon repair using fiberwire," *Journal of Hand Surgery*, vol. 33, no. 5, pp. 701–708, 2008.

[12] D. Greenwald, S. Shumway, P. Albear, and L. Gottlieb, "Mechanical comparison of 10 suture materials before and after in vivo incubation," *Journal of Surgical Research*, vol. 56, no. 4, pp. 372–377, 1994.

[13] V. Mishra, J. H. Kuiper, and C. P. Kelly, "Influence of core suture material and peripheral repair technique on the strength of Kessler flexor tendon repair," *Journal of Hand Surgery*, vol. 28, no. 4, pp. 357–362, 2003.

[14] J. S. Taras, J. S. Raphael, S. C. Marczyk, and W. B. Bauerle, "Evaluation of suture caliber in flexor tendon repair," *Journal of Hand Surgery*, vol. 26, no. 6, pp. 1100–1104, 2001.

[15] G. Alavanja, E. Dailey, and D. P. Mass, "Repair of zone II flexor digitorum profundus lacerations using varying suture sizes: a comparative biomechanical study," *Journal of Hand Surgery*, vol. 30, no. 3, pp. 448–454, 2005.

[16] I. Kessler and F. Nissim, "Primary repair without immobilization of flexor tendon division within the digital sheath. An experimental and clinical study," *Acta Orthopaedica Scandinavica*, vol. 40, no. 5, pp. 587–601, 1969.

[17] D. G. Pennington, "The locking loop tendon suture," *Plastic and Reconstructive Surgery*, vol. 63, no. 5, pp. 648–652, 1979.

[18] R. Savage, "In vitro studies of a new method of flexor tendon repair," *Journal of Hand Surgery*, vol. 10, no. 2, pp. 135–141, 1985.

[19] M. D. Shaieb and D. I. Singer, "Tensile strengths of various suture techniques," *Journal of Hand Surgery*, vol. 22, no. 6, pp. 764–767, 1997.

[20] K. L. Silfverskiöld and C. H. Andersson, "Two new methods of tendon repair: an in vitro evaluation of tensile strength and gap formation," *Journal of Hand Surgery*, vol. 18, no. 1, pp. 58–65, 1993.

[21] A. Viinikainen, H. Göransson, K. Huovinen, M. Kellomäki, and P. Rokkanen, "A comparative analysis of the biomechanical behaviour of five flexor tendon core sutures," *Journal of Hand Surgery*, vol. 29, no. 6, pp. 536–543, 2004.

[22] D. W. Sanders, A. D. Milne, A. Dobravec, J. Macdermid, J. A. Johnson, and G. J. W. King, "Cyclic testing of flexor tendon repairs: an in vitro biomechanical study," *Journal of Hand Surgery*, vol. 22, no. 6, pp. 1004–1010, 1997.

[23] M. Aoki, P. R. Manske, D. L. Pruitt, and B. J. Larson, "Work of flexion after tendon repair with various suture methods—a human cadaveric study," *Journal of Hand Surgery*, vol. 20, no. 3, pp. 310–313, 1995.

[24] J. G. Angeles, H. Heminger, and D. P. Mass, "Comparative biomechanical performances of 4-strand core suture repairs for zone II flexor tendon lacerations," *Journal of Hand Surgery*, vol. 27, no. 3, pp. 508–517, 2002.

[25] E. McLarney, H. Hoffman, and S. W. Wolfe, "Biomechanical analysis of the cruciate four-strand flexor tendon repair," *Journal of Hand Surgery*, vol. 24, no. 2, pp. 295–301, 1999.

[26] M. Vigler, R. Palti, R. Goldstein, V. P. Patel, P. Nasser, and S. K. Lee, "Biomechanical study of cross-locked cruciate versus strickland flexor tendon repair," *Journal of Hand Surgery*, vol. 33, no. 10, pp. 1826–1833, 2008.

[27] T. M. Lawrence, M. J. Woodruff, A. Aladin, and T. R. C. Davis, "An assessment of the tensile properties and technical difficulties of two- and four-strand flexor tendon repairs," *Journal of Hand Surgery*, vol. 30, no. 3, pp. 294–297, 2005.

[28] C. Healy, K. J. Mulhall, D. J. Bouchier-Hayes, and B. Kneafsey, "Practice patterns in flexor tendon repair," *Irish Journal of Medical Science*, vol. 176, no. 1, pp. 41–44, 2007.