# Biomechanical Strength Comparison Between Pulvertaft Weave and Side-to-Side Tendon Repair: A Meta-Analysis and Systematic Review

*Carlos Miguel Santos, MD,*[1] *John Hubert Pua, MD, MHPEd*[1,2]

## ABSTRACT

**Background:** To compare biomechanical strength of the Pulvertaft (PT) weave and the side-to-side (STS) tendon repair techniques.

**Methods:** We conducted a comprehensive literature search using PubMed, MEDLINE and Cochrane library from inception to November 2020. All studies comparing the PT weave and STS were included. Methodological quality and assessment of risk of bias were assessed by two independent researchers. Publication bias was assessed using a funnel plot and confirmed by the Begg's and Egger's test. The random effects mode was used due to both statistical and clinical heterogeneity among studies.

**Results:** The initial search resulted in 624 articles; however, after a thorough review, only six studies were selected for inclusion in the meta-analysis and systematic review. We were able to pool findings for maximum load and load to failure. By definition, maximum load is the peak force achieved in tensile testing while load to failure is the first negative inflection of force during the failure test. For maximum load, results showed that there was no evidence that the two tendon repair techniques were significantly different (SMD = –0.84, z = 0.88, $p$ = 0.379, 95% CI = –2.72 – 1.04). However, there was significantly high heterogeneity detected among the included studies (Q=21.10, $p$ = 0.001, $I^2$ = 90.50%, $\tau^2$ = 2.47). For load to failure, results indicated that the load to failure was statistically higher in the side-to-side approach (SMD = 1.36, z = 5.26, $p$ = 0.001, 95% CI = 0.85 – 1.86) than the PT approach. It is also notable that a small, non-significant heterogeneity was detected among the included studies (Q=3.66, $p$ = 0.300, $I^2$ = 18.10%, $\tau^2$ = 0.05).

**Conclusion:** STS is stronger than PT weave in terms of load to failure but comparable in terms of maximum load. STS is a possible alternative to PT weave for tendons in need of grafting.

**Keywords:** Pulvertaft weave, side-to-side repair, biomechanical strength, tendon repair, tendon graft

## INTRODUCTION

Tendon repair in the hand has been a continuously developing topic in the field of orthopaedic surgery. Various properties and types of tendon repair have been studied throughout the years and in conjunction with this, postoperative protocols or rehabilitation methods have been influenced as well.

✉ Carlos Miguel Santos
carlosmiguelb.santos@gmail.com

1 Department of Orthopedics, University of Santo Tomas Hospital, Manila, Philippines

2 Faculty of Medicine and Surgery, University of Santo Tomas, Manila, Philippines

Academic editor: Warren Bacorro

Submitted date: June 15, 2023

Accepted date: March 02, 2025

Hand surgeons should be knowledgeable about the possible choices for tendon repair and postoperative care that follows. For this study, the authors focused on the concept of early mobilization after tendon repair. Studies have shown that early mobilization can contribute to the reduction of adhesion formation and reduction of postoperative recovery time is possible by improving the range of motion and tensile strength of the tendon.[1–4] On the other hand, excessive strain placed on the repaired tendon during motion can also lead to rupture. One of the factors that could help with this dilemma is the strength of the tendon repair construct.[5,6]

The Pulvertaft (PT) weave has been one of the more widely used techniques for tendon repair and considered by some as the "gold standard." Classically, the technique involves the distal tendon woven through three incisions in the proximal tendon and these weaves are inserted orthogonally before sutures are placed.[7–9] The side-to-side (STS) tendon repair provides us with another technique that is said to show properties that are equal or even greater than the PT while being less cumbersome in technique.[5,10,11]

## METHODOLOGY

### Search strategy and selection criteria

We conducted a comprehensive literature search using PubMed, Cochrane Library and Google Scholar from August 2020 to November 2020. Electronic searchers were performed and included: "Tendon" AND "Repair" AND "Graft*" AND/OR "Pulvertaft"

After the search was done, the authors then selected possible articles to be reviewed. The titles and abstracts were read to classify possible articles. Articles considered were included if they met the inclusion criteria; *clinical trials/experimental studies, in vitro* or *in vivo, comparison of the PT weave to the STS* and *outcomes that compared biomechanical properties*. Potential articles were then retrieved and screened by way of full text eligibility. In addition, the reference section of each potential article was reviewed to identify other eligible studies not captured by the initial search.

### Assessment of Risk of Bias

Two investigators assessed the risk of bias of each included study independently. In the instance of inconsistency between the two, the research adviser would resolve the conflict and come up with a consensus. Risk of bias was assessed using the Risk of Bias In Non-Randomized Studies of Interventions (ROBINS-I). As in the tool for randomized trials, risk of bias was assessed within specified bias domains, and review authors were asked to document the information on which judgments were based. The studies were assessed as low risk, moderate risk, serious risk, critical risk or no information according to the following domains: confounding variables, selection of participants into the study, classification of interventions, deviations from intended intervention, missing data, measurement of outcomes and selection of reported results.

### Data Extraction and Analysis

Statistical analyses were conducted using STATA MP Statistical Software, Version 13, College Station, TX: StataCorp LP. A $p$-value $\leq 0.05$ was considered statistically significant. Since this study did not assume one effect size among all the studies, the overall effect of the meta-analysis was derived using a random-effects model (REM), which takes within-study and between-study variation into account. However, should a study have no heterogeneity, analysis was conducted using fixed-effects model (FEM). Standardized mean difference was used to pool the effect measure of continuous-level outcomes (maximum load and load to failure).

Statistical heterogeneity between studies were scrutinized using Q statistics test, $I^2$ statistics and tau squared ($\tau^2$) statistics (Higgins, 2003). $I^2$ values greater than 50% imply substantial heterogeneity (Higgins, 2003). Publication bias was assessed using both graphical and statistical approaches. Graphical approach for publication bias included contour-enhanced funnel plots, while statistical assessment of funnel plot asymmetry was performed using Begg's asymmetry test (Higgins, 2003).

### Results

The literature search yielded a total of 624 results. After duplicates and articles were screened, there were 53 articles for full text eligibility. The remaining six studies were included in this meta-analysis and systematic review (Table 1). All the six studies compared PT and STS. One study also compared

**Table 1:** Characteristics of Included Studies

| | Tendons Used | Number of Tendons | Repair Technique Comparison | Summary of Technique Used | Anchor sites, Suture and Pattern Used | Testing Machine | Outcome measures |
|---|---|---|---|---|---|---|---|
| Sajid, et.al. (2020) | Porcine | 20 | PT vs STS | (Figure 5)<br>STS: Slit is made on the recipient and the donor tendon is passed through the slit and the overlapping tendons are then sutured together<br>PT: Three slits are made on the recipient tendon and the donor tendon is passed through all three slits perpendicular to each other | 8 anchor sites (3-0 polyester) Cross suture pattern<br><br>6 anchor sites (3-0 polyester) Box type mattress | Servo mechanical testing machine | Cyclic loading at 25N<br>Cyclic loading at 75N<br>Load to Failure |
| Kannan, et.al. (2019) | Turkey | 34 | PT vs STS | (Figure 6)<br>STS: A slit is made on the recipient tendon and the donor tendon is passed through the slit and overlapping tendons are then sutured together<br>PT: A slit is made on both the recipient and donor tendon. The donor tendon passes through the slit on the recipient tendon and the recipient tendon passes through slit on the donor tendon. Overlapping tendons are sutured together | 8 anchor sites (3-0 braided sutures) Simple suture pattern<br><br>8 anchor sites (3-0 braided sutures) Simple suture pattern | Instron tensile testing machine | Maximum load<br>Load to failure<br>Load at break<br>Site of failure<br>Tensile stress<br>Tensile strain |
| Rivlin, et.al. (2016) | Human cadaver | 30 | PT vs STS | (Figure 7)<br>STS: Slit is made on the recipient and the donor tendon is passed through the slit and the overlapping tendons are then sutured together<br>PT: Three slits are made on the recipient tendon and the donor tendon is passed through all three slits perpendicular to each other | 10 anchor sites (3-0 polyester) Cross stitch with double loop<br><br>10 anchor sites (3-0 polyester) Horizontal mattress stitch with double loop | Eden Prairie tensile testing machine | Bulk site<br>Load to failure<br>Strength ratio |

**Table 1:** Characteristics of Included Studies

| | Tendons Used | Number of Tendons | Repair Technique Comparison | Summary of Technique Used | Anchor sites, Suture and Pattern Used | Testing Machine | Outcome measures |
|---|---|---|---|---|---|---|---|
| Brown, et.al. (2010) | Human cadaver | 13 | PT vs STS | (Figure 8)<br>STS: Slit is made on the recipient and the donor tendon is passed through the slit and the overlapping tendons are then sutured together<br>PT: Three slits are made on the recipient tendon and the donor tendon is passed through all three slits perpendicular to each other | 10 anchor sites (3-0 polyester) Cross stitch with double loop<br><br>10 anchor sites (3-0 polyester) Horizontal mattress stitch with double loop | Instron tensile testing machine | Maximum load<br>Load to failure<br>Repair stiffness |
| Bidic, et.al. (2009) | Porcine | 30 | Lasso vs PT vs STS | (Figure 9)<br>Lasso: A slit is made on the recipient tendon, then the donor tendon is passed through the slit. A slit is then made on the donor tendon so that it can be woven through itself<br>PT: Three slits are made on the recipient tendon and the donor tendon is passed through all three slits perpendicular to each other<br>STS: The tendons are positioned side by side with an overlap and sutured together | 6 anchor sites (4-0 ethicon) Simple suture | Instron tensile testing machine | Maximum load<br>Tendon length required<br>Bulkiness<br>Weave time |
| Tsiampa, et.al. (2012) | Sheep | 15 | STS vs PT | (Figure 10)<br>STS: Slit is made on the recipient and the donor tendon is passed through the slit and the overlapping tendons are then sutured together<br>PT: Three slits are made on the recipient tendon and the donor tendon is passed through all three slits perpendicular to each other | 18 anchor sites (3-0 polyester) Cross stitch with double loop<br><br>18 anchor sites (3-0 polyester) Mattress suture with double loop | Eden Prairie tensile testing machine | Load to failure<br>Maximum tendon construct elongation |

**Table 2:** Statistical Assessment of Publication Bias Among the Included Studies

| Outcome | Number of Included Studies | Begg's Test | | Egger's Test | |
|---|---|---|---|---|---|
| | | *z*-test | *p*-value (Two-Tailed) | Bias | *p*-value (Two-Tailed) |
| **Maximum Load** | 3 studies | 1.04 | 0.296 | –6.03 | 0.460 |
| **Load to Failure** | 4 studies | 0.34 | 0.734 | 1.67 | 0.359 |

the two techniques to another technique, loop technique but was still included in this analysis. All studies were done in vitro. With respect to the source of tendons, one study used turkey tendons, another used sheep, two studies used porcine, and two studies used human cadavers. Among the studies, all provided details on how they proceeded to do the repair technique. The risk of bias for the studies ranged from low to moderate risk. This can be seen in more detail in Table 3. As of the search of this study, there were no local studies found.

### Pooled Estimate for Maximum Load Between Side-to-Side and Pulvertaft Weave Tenorrhaphy

Figure 2 illustrates the pooled summary effect for maximum load between STS and PT weave tenorrhaphy. A total of three eligible and complete studies were included, with a total of 36 specimens in the STS approach and 37 specimens in the PT weave tenorrhaphy. Results showed that there was no evidence that the two tendon repair techniques were significantly different (SMD = –0.84, z = 0.88, $p$ = 0.379, 95% CI = –2.72 – 1.04). However, there was significantly high heterogeneity detected among the included studies (Q=21.10, $p$ = 0.001, $I^2$ = 90.50%, $\tau^2$ = 2.47).

### Pooled Estimate for Load to Failure Between Side-to-Side and Pulvertaft Weave Tenorrhaphy

The pooled estimate for the load to failure outcome between the two tendon repair techniques is depicted in Figure 3. It can be noted that a total of four complete studies were included, involving a total of 83 specimens in the STS approach and 85 specimens in the PT weave tenorrhaphy. Analysis indicated that the load to failure was statistically higher in the STS approach (SMD = 1.36, z = 5.26, $p$ = 0.001, 95% CI = 0.85 – 1.86) than the PT approach. It is also notable that a small, non-significant heterogeneity was detected among the included studies (Q=3.66, $p$ = 0.300, $I^2$ = 18.10%, $\tau^2$ = 0.05).

### Publication Bias Assessment

The graphical analysis of publication bias using contour-enhanced funnel plots are presented in Figure 4. It can be noted in the funnel plot for maximum load that there is no evidence of funnel asymmetry; however, the funnel plot for load before failure does indicate the likelihood of funnel asymmetry. Nonetheless, statistical analyses using Begg's Test and Egger's Test (Table 2) suggest that publication bias among the included studies were unlikely.

## DISCUSSION

The PT weave is the standard for tendon grafting due to its strength and reliability. As such, it has been subjected to numerous studies that test its different properties with various modifications.[12–14] Recent studies have also compared it to other techniques in order to make up for its disadvantages.[5,6,11,13,15–17] These would include its bulkiness, the amount of tendon length needed to create the construct and the technique itself is demanding. One of these new techniques that is being compared to the gold standard is the STS tendon repair. It is a technique that was created to make up for some of the limitations of the PT weave while not comprising tensile strength. To the knowledge of the authors, this is the first meta-analysis and systematic review comparing the biomechanical properties of the STS technique to the PT weave, more specifically the maximum load and load to failure of the tendon repair techniques. As defined, maximum load is the peak force achieved in tensile testing while load to failure is the first negative inflection of force during the failure test.

All studies explained how the techniques were done. The standard PT weave technique was followed by most studies, however, the study by Kannan

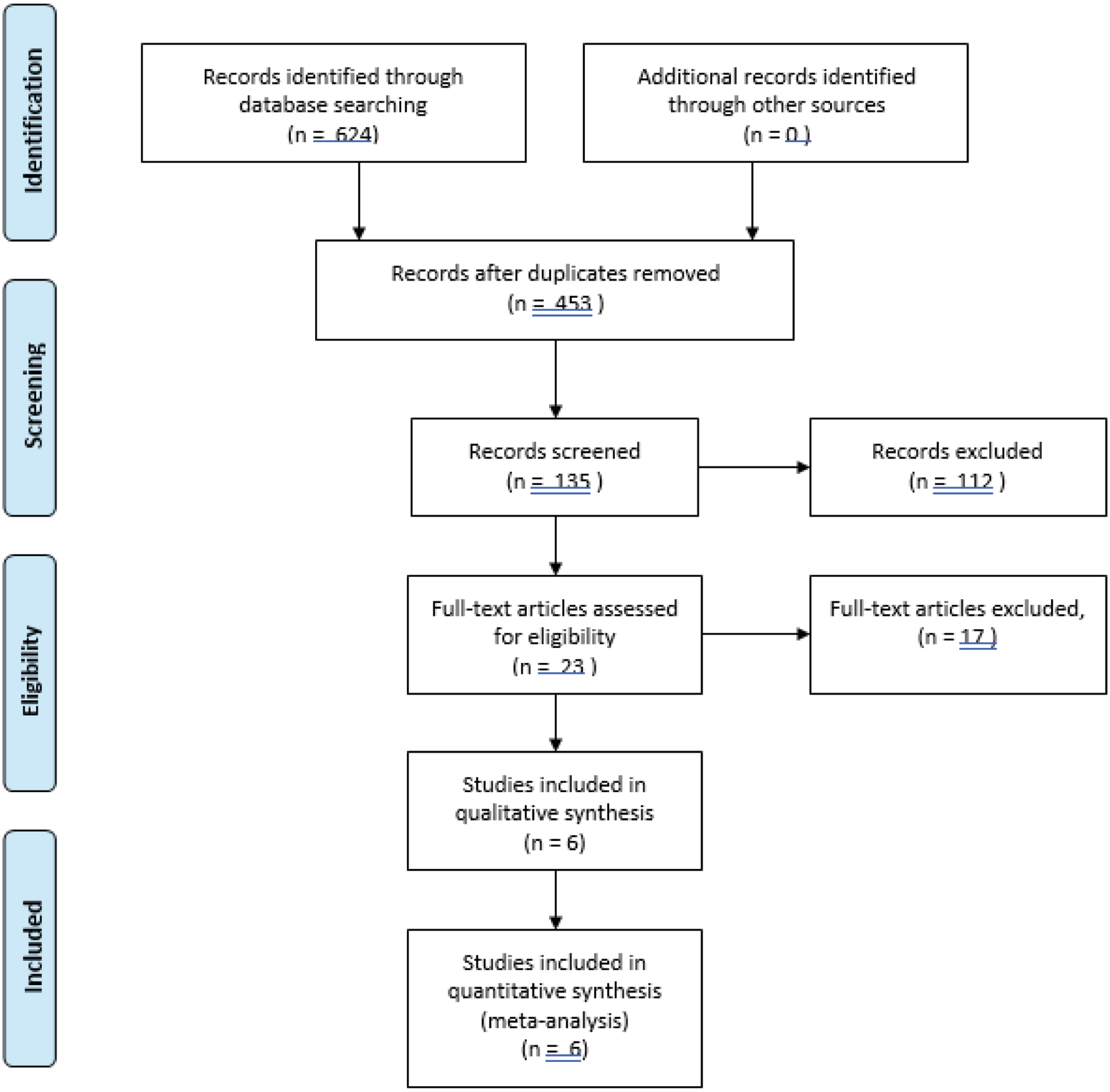


**Figure 1:** Flow diagram for selecting studies

modified the technique because of standardization. For the STS repair, two studies deviated from the standard STS technique. Kannan, et.al. added sutures to both donor and recipient tendon. Bidic, et.al., on the other hand, did not incorporate a weave into the STS technique and sutured both overlapping tendons together.

Maximum load was found not to be significant in this study. This can be attributed to the variation in technique that the studies used. As mentioned, one study sutured the tendons in overlapping sites, but the donor tendon did not pass through a weave of the recipient tendon.

For the maximum load, there was considerable heterogeneity found between the studies while for the load to failure, only small amount of heterogeneity was found. To further analyze heterogeneity, a subgroup and meta-regression analysis was attempted, however, due to the small sample size, it was not possible. A funnel plot was then created to detect if there was any publication bias that could be the cause of heterogeneity. The funnel plots showed

**Table 3:** Risk of Bias Analysis of Included Studies Using the Cochrane Collaboration's Risk of Bias in Non-Randomized Studies of Interventions (ROBINS-1) Assessment Tool

| | Areas of Assessment | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Study (Year) and Country** | **Bias due to Confounding** | **Bias in Selection of Participants** | **Bias in Classification of Intervention** | **Bias due to Deviation from Intended Interventions** | **Bias due to Missing Data** | **Bias in Outcome Measurement** | **Bias in Selection of Reported Results** | **Overall Level of Risk** |
| Kannan, et.al. (2019) UK | Moderate risk | Low risk | Low risk | Low risk | Low risk | Low risk | Low risk | Moderate risk |
| Sajid, et.al. (2020) UK | Low risk | Low risk | Low risk | Low risk | Low risk | Low risk | Low risk | Low risk |
| Rivlin, et.al. (2016) US | Moderate risk | Low risk | Low risk | Low risk | Low risk | Low risk | Low risk | Moderate risk |
| Brown, et.al. (2010) US | Low risk | Low risk | Low risk | Low risk | Moderate risk | Low risk | Moderate risk | Moderate risk |
| Bidic, et.al. (2009) US | Low risk | Low risk | Low risk | Low risk | Low risk | Low risk | Low risk | Low risk |
| Tsiampa, et.al. (2012) EU | Low risk | Low risk | Low risk | Low risk | Low risk | Low risk | Moderate risk | Moderate risk |

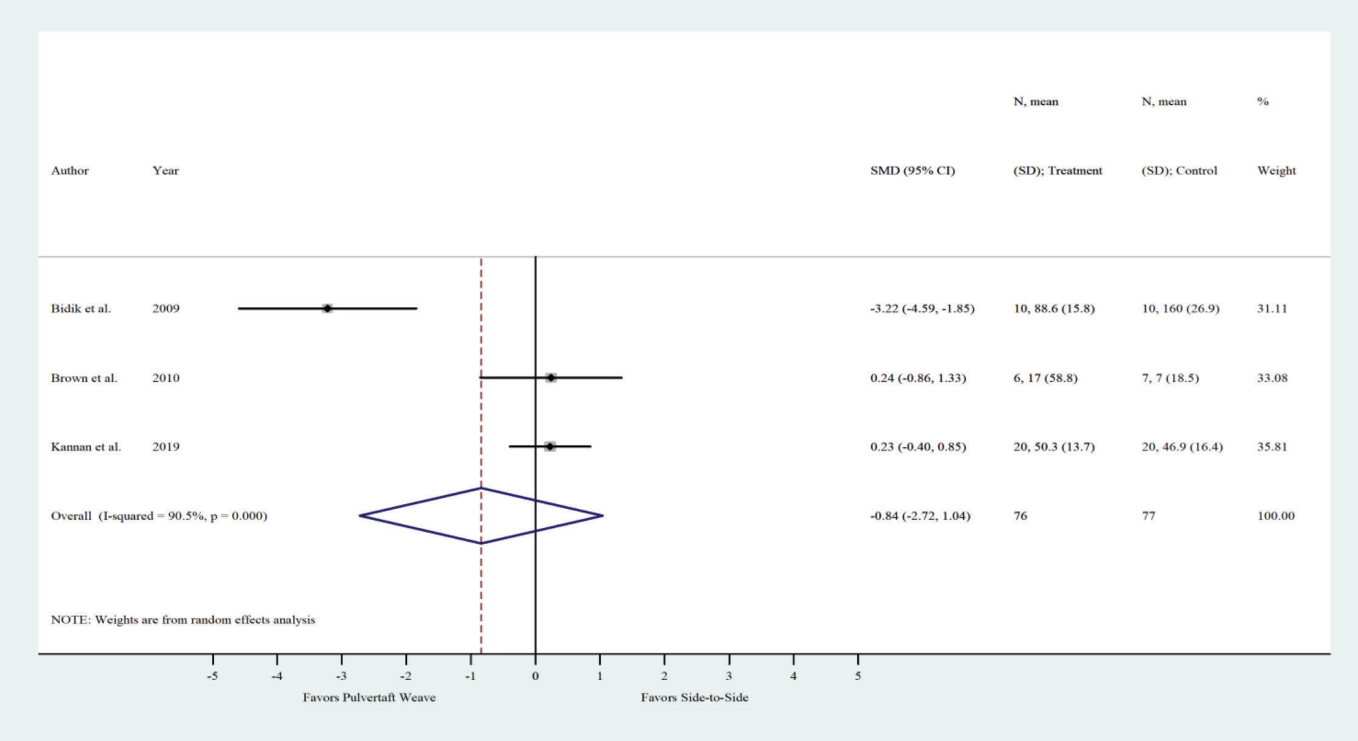


**Figure 2:** Forest plot of maximum load between studies

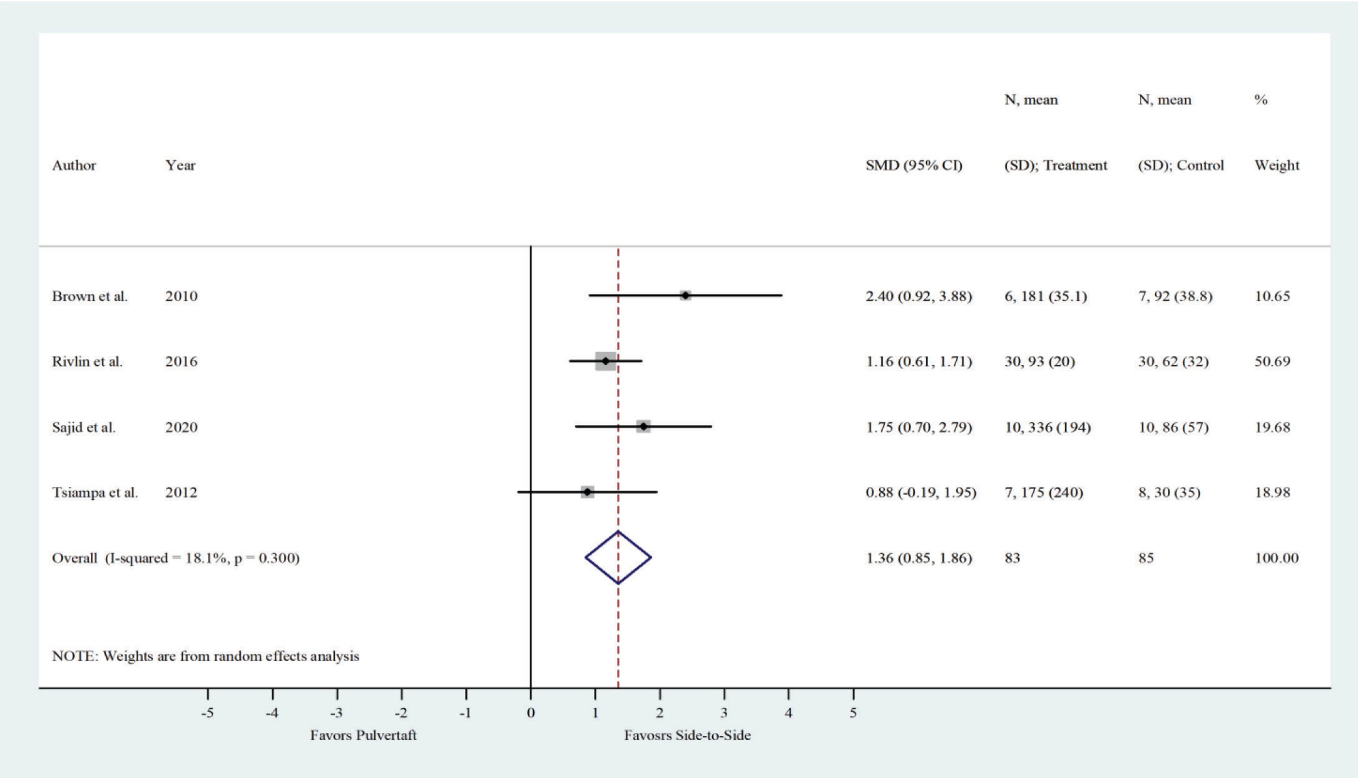


**Figure 3:** Forest plot of load to failure

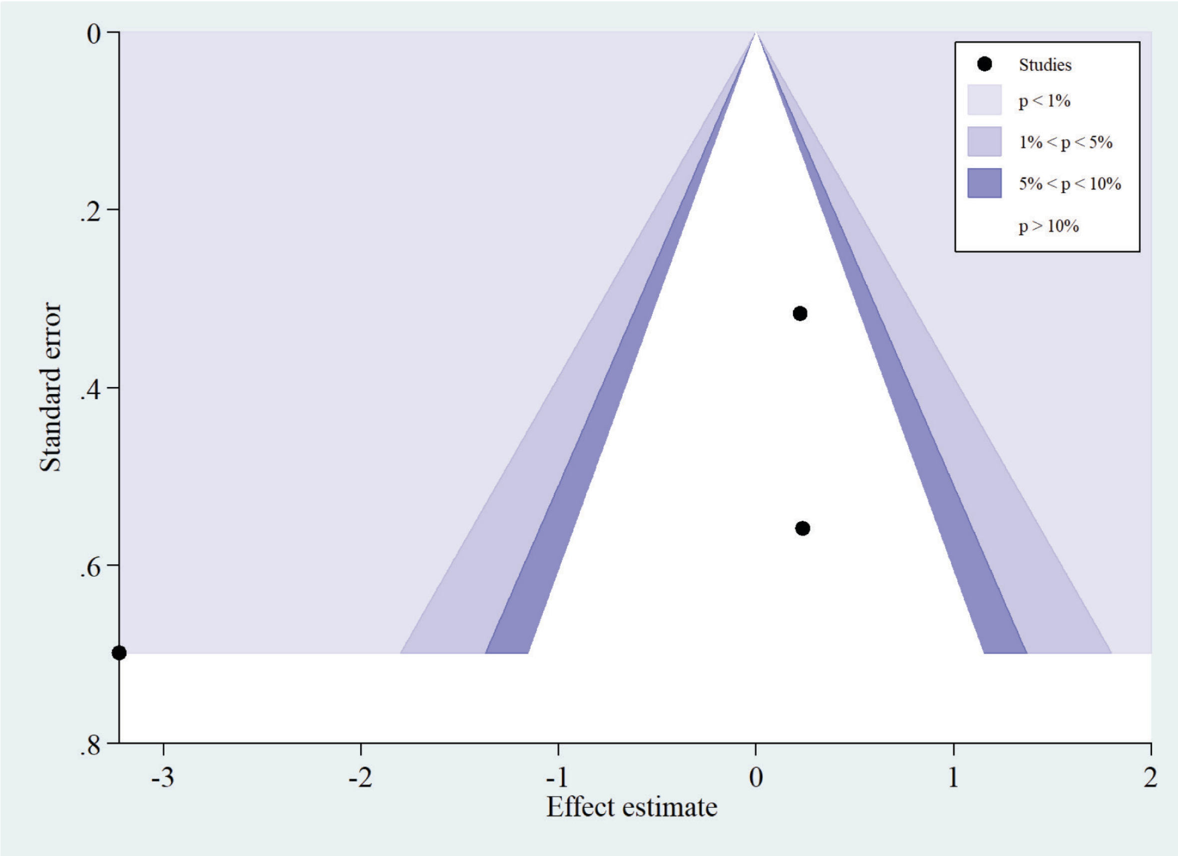


**Figure 4:** Funnel plot for maximum load (left) and load to failure (right)

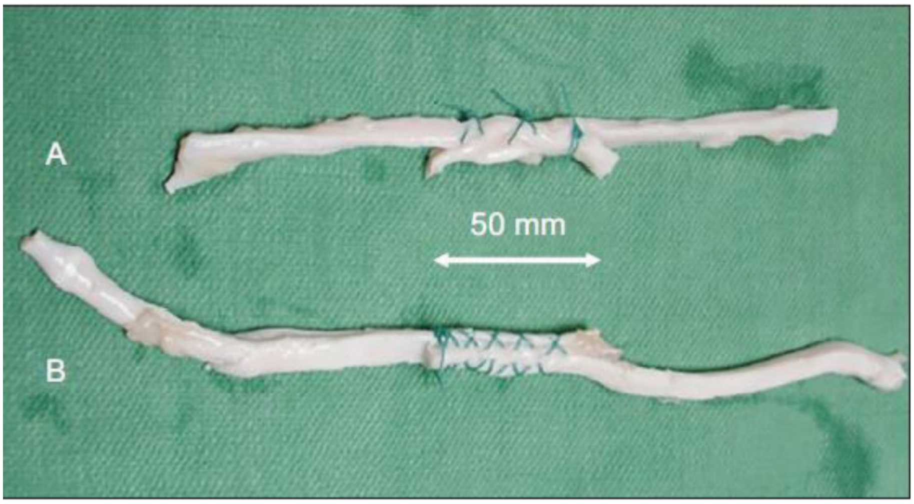


**Figure 5:**[22] A. Pulvertaft weave B. Side-to-side repair

for both outcome measures that publication bias was not the case. Additionally, a Begg's test and Egger's test confirmed this. Aside from the limitations of this study, possible causes of heterogeneity are the small number of studies available and thus, the small sample size as well.

One of the evidences that display the STS having a higher load to failure could be the site of failure. Most of the studies noted their observation on how the tendon graft failed. For the PT, these included slipped suture knots or the donor tendon pulled through the recipient tendon. For the STS, these

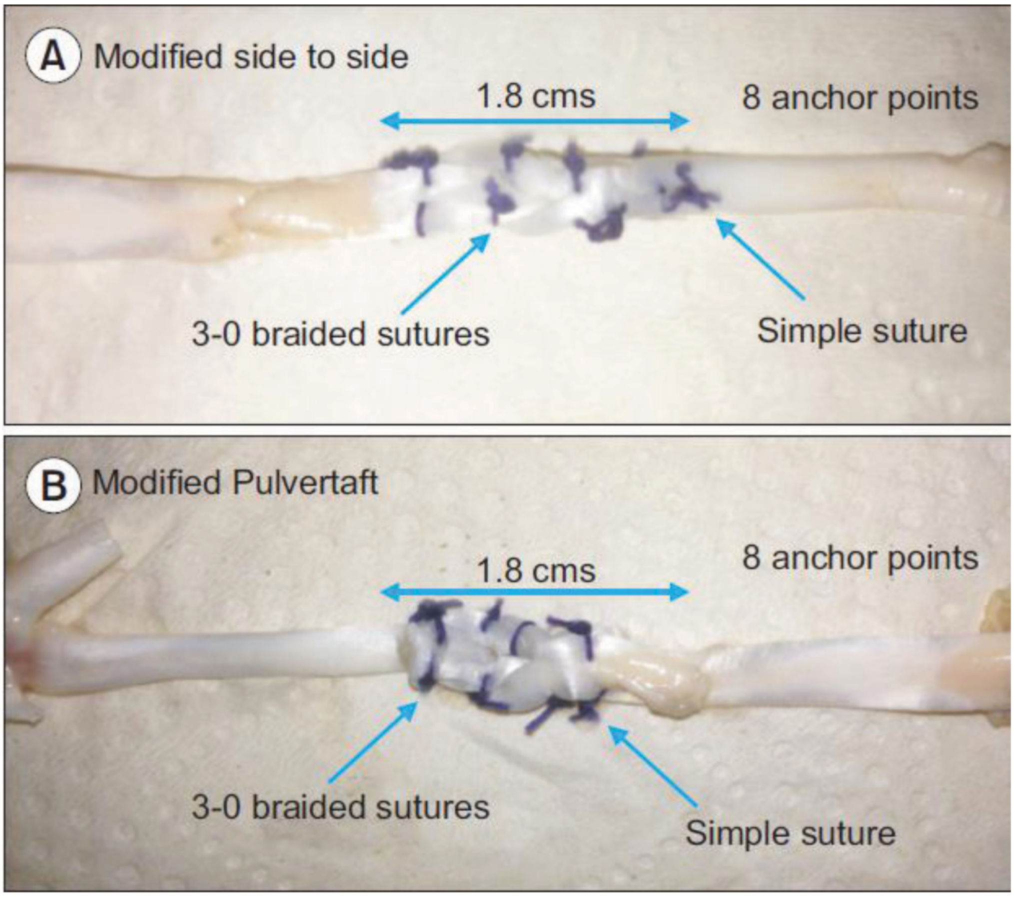


**Figure 6:** A. Modified side-to-side B. Modified Pulvertaft

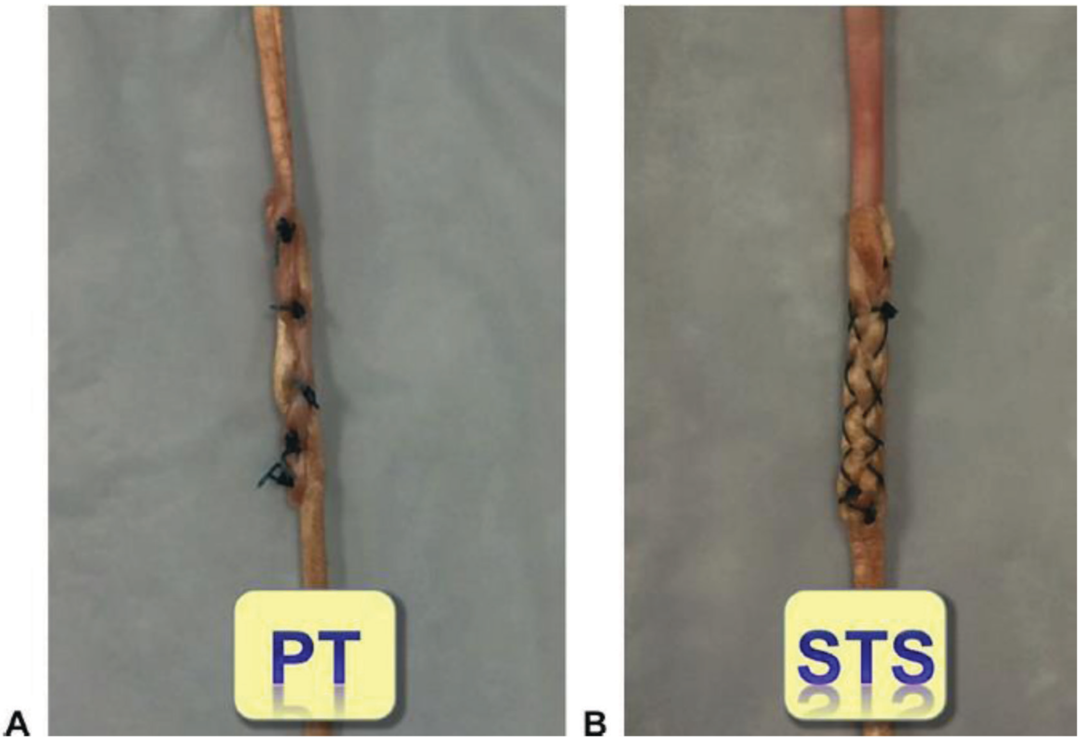


**Figure 7:** A. Pulvertaft weave B. Side-to-side

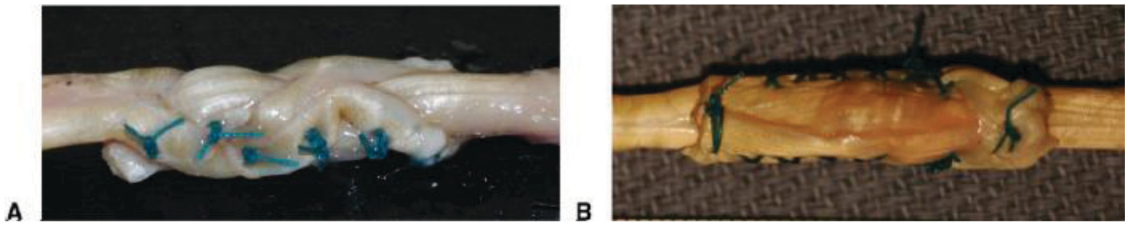

**Figure 8:** A. Pulvertaft weave B. Side-to-side

**Figure 9:** On the left is the Pulvertaft weave. Right is the side-to-side

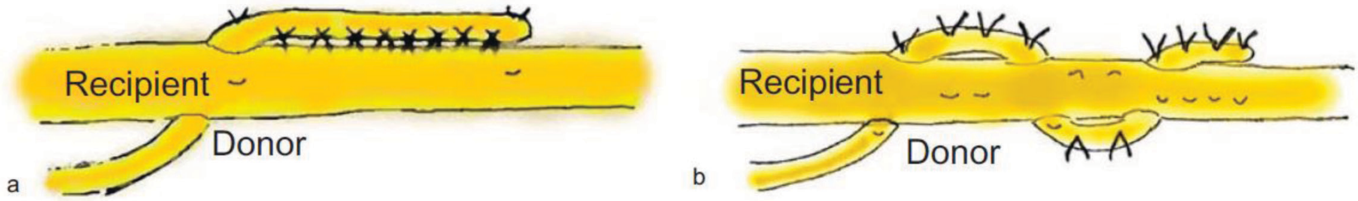


**Figure 10:** A. Side-to-Side B. Pulvertaft Weave

included longitudinal shear of the tendon from the repair site and failure of the site as well. One could attribute it to the number of weaves of the PT because the STS only has one weave. However, a recent study by Choke (2019), investigated the difference in strength of a PT weave with varying number of weaves. They concluded that the two weaves are a suitable number.

One limitation to this study is their in-vitro nature of the studies. This would let the researchers test the outcomes measurable by a tensile testing machine of the repair technique. It does not consider other important factors of tendon healing such as friction, adhesion formation and vascular healing properties provided by the tendons which can be provided by studies in vivo. Another weakness is that while most of the studies followed the protocol for the technique, others made modifications. Lastly, the source of tendons can also be a factor. However, there are studies that have shown that porcine, sheep and turkey can be used in tendon graft studies.[18–22]

## CONCLUSION

The PT weave and STS techniques were created to aid patients towards early mobilization which in turn, could lead to better and faster patient outcome. In conclusion, this study evaluated the biomechanical properties of the PT and STS techniques in terms of maximum load and load to failure. The PT weave remains the gold standard for tendon grafting due to its strength and reliability, the STS technique showed encouraging results in terms of load to failure while also making up for some of the drawbacks of the PT weave such as its bulkiness and complexity.

The analysis found no significant difference in maximum load between the two techniques which could be attributed to differences in study protocols. However, there was evidence supporting that STS may have higher load to failure. Tendon failure locations further supported this, with PT failing linked to slipped sutures or donor tendon pull-through while STS failed because of longitudinal shear of the tendon.

Despite these findings for the STS technique, there were limitations such as the in vitro nature of the studies, variations with protocol and source of tendon materials. The sample size and potential heterogeneity in studies were also factors that could impact results. Further research should entail the use of in vivo models and more standardized methods to offer a clearer comparison between the two techniques.

## REFERENCES


1. Khan K, Riaz M, Murison MS, Brennen MD. Early active mobilization after second stage flexor tendon grafts. *J Hand Surg Br* [Internet]. 1997;22(3):372–4. Available from: https://doi.org/10.1016/s0266-7681(97)80404-4
2. Pettengill KM. The evolution of early mobilization of the repaired flexor tendon. *J Hand Ther* [Internet]. 2005;18(2):157–68. Available from: https://doi.org/10.1197/j.jht.2005.01.007
3. Tonkin M, Hagberg L, Lister G, Kutz J. Post-operative management of flexor tendon grafting. *J Hand Surg Br* [Internet]. 1988;13(3):277–81. Available from: https://doi.org/10.1016/0266-7681_88_90085-x
4. Vucekovich K, Gallardo G, Fiala K. Rehabilitation after flexor tendon repair, reconstruction, and tenolysis. *Hand Clin* [Internet]. 2005;21(2):257–65. Available from: https://doi.org/10.1016/j.hcl.2004.11.006
5. Rivlin M, Eberlin KR, Kachooei AR, Hosseini A, Zivaljevic N, Li G, et al. Side-to-side versus Pulvertaft extensor tenorrhaphy-A biomechanical study. *J Hand Surg Am* [Internet]. 2016;41(11):e393–7. Available from: https://doi.org/10.1016/j.jhsa.2016.07.106
6. Kannan S, Ghosh AI, Dias JJ, Singh HP. Comparative biomechanical characteristics of modified side-to-side repair and modified pulvertaft weaving repair - in vitro study. *J Hand Surg Asian Pac Vol* [Internet]. 2019;24(1):76–82. Available from: https://doi.org/10.1142/S2424835519500140
7. Pulvertaft RG. Tendon grafts for flexor tendon injuries in the fingers and thumb; a study of technique and results. *J Bone Joint Surg Br* [Internet]. 1956;38-B(1):175–94. Available from: https://doi.org/10.1302/0301-620X.38B1.175
8. Gabuzda GM, Lovallo JL, Nowak MD. Tensile strength of the end-weave flexor tendon repair. An in vitro biomechanical study. *J Hand Surg Br* [Internet]. 1994;19(3):397–400. Available from: https://doi.org/10.1016/0266-7681(94)90098-1
9. Strandenes E, Ellison P, Mølster A, Gjerdet NR, Moldestad IO, Høl PJ. Strength of Pulvertaft modifications: tensile testing of porcine flexor tendons. *J Hand Surg Eur Vol* [Internet]. 2019;44(8):795–9. Available from: https://doi.org/10.1177/1753193419841522
10. Fridén J, Tirrell TF, Bhola S, Lieber RL. The mechanical strength of side-to-side tendon repair with mismatched tendon size and shape. *J Hand Surg Eur Vol* [Internet]. 2015;40(3):239–45. Available from: https://doi.org/10.1177/1753193413517327
11. Brown SHM, Hentzen ER, Kwan A, Ward SR, Fridén J, Lieber RL. Mechanical strength of the side-to-side versus Pulvertaft weave tendon repair. *J Hand Surg Am* [Internet]. 2010;35(4):540–5. Available from: https://doi.org/10.1016/j.jhsa.2010.01.009
12. Tanaka T, Zhao C, Ettema AM, Zobitz ME, An K-N, Amadio PC. Tensile strength of a new suture for fixation of tendon grafts when using a weave technique. *J Hand Surg Am* [Internet]. 2006;31(6):982–6. Available from: https://doi.org/10.1016/j.jhsa.2006.03.020
13. Vincken NLA, Lauwers TMAS, van der Hulst RRWJ. Biomechanical and dimensional measurements of the Pulvertaft weave versus the cow-hitch technique. *Hand (N Y)* [Internet]. 2017;12(1):78–84. Available from: https://doi.org/10.1177/1558944716646758
14. Choke A, Rung WY, McGrouther DA, Bin Abd Razak HR. The strengths of one-, two-, and three-weave Pulvertaft tendon repairs. *J Hand Surg Eur Vol* [Internet]. 2020;45(10):1051–4. Available from: https://doi.org/10.1177/1753193420926097
15. De Smet L, Schollen W, Degreef I. In vitro biomechanical study to compare the double-loop technique with the Pulvertaft weave for tendon anastomosis. *Scand J Plast Reconstr Surg Hand Surg* [Internet]. 2008;42(6):305–7. Available from: https://doi.org/10.1080/02844310802401330
16. Bidic SM, Varshney A, Ruff MD, Orenstein HH. Biomechanical comparison of lasso, Pulvertaft weave, and side-by-side tendon repairs. *Plast Reconstr Surg* [Internet]. 2009;124(2):567–71. Available from: https://doi.org/10.1097/PRS.0b013e3181addb8f
17. Sajid S, Day E, Kuiper JH, Singh R, Pickard S. Biomechanical evaluation comparing pulvertaft weave and side-to-side tenorrhaphy using porcine tendons. *J Hand Surg Asian Pac Vol* [Internet]. 2020;25(4):447–52. Available from: https://doi.org/10.1142/S2424835520500496
18. Domnick C, Wieskötter B, Raschke MJ, Schulze M, Kronenberg D, Wefelmeier M, et al. Evaluation of biomechanical properties: are porcine flexor tendons and bovine extensor tendons eligible surrogates for human tendons in in vitro studies? *Arch Orthop Trauma Surg* [Internet]. 2016;136(10):1465–71. Available from: https://doi.org/10.1007/s00402-016-2529-2
19. Hausmann J-T, Vekszler G, Bijak M, Benesch T, Vécsei V, Gäbler C. Biomechanical comparison of modified Kessler and running suture repair in 3 different animal tendons and in human flexor tendons. *J Hand Surg Am* [Internet]. 2009;34(1):93–101. Available from: https://doi.org/10.1016/j.jhsa.2008.09.015
20. Kadar A, Thoreson AR, Reisdorf RL, Amadio PC, Moran SL, Zhao C. Turkey model for flexor tendon research: in vitro comparison of human, canine, turkey, and chicken tendons. *J Surg Res* [Internet]. 2017;216:46–55. Available from: https://doi.org/10.1016/j.jss.2017.03.035
21. Peltz TS, Hoffman SW, Scougall PJ, Gianoutsos MP, Savage R, Oliver RA, et al. Animal models for tendon repair experiments: A comparison of pig, sheep and human deep flexor tendons in Zone II. *J Hand Surg Asian Pac Vol* [Internet]. 2017;22(3):329–36. Available from: https://doi.org/10.1142/S0218810417500381
22. Smith AM, Forder JA, Annapureddy SR, Reddy KSK, Amis AA. The porcine forelimb as a model for human flexor tendon surgery. *J Hand Surg Br* [Internet]. 2005;30(3):307–9. Available from: https://doi.org/10.1016/j.jhsb.2005.02.003
23. Tsiampa VA, Ignatiadis I, Papalois A, Givissis P, Christodoulou A, Fridén J. Structural and mechanical integrity of tendon-to-tendon attachments used in upper limb tendon transfer surgery. *J Plast Surg Hand Surg* [Internet]. 2012;46(3–4):262–6. Available from: https://doi.org/10.3109/2000656X.2012.684097