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Review Article

A comparative meta-analysis between mini-transverse and longitudinal techniques in the management of carpal tunnel syndrome

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ABSTRACT

Background: Due to the gap and the controversy regarding whether to use the traditional open technique or the minimally invasive technique in carpal tunnel syndrome, we carried out this systematic review and meta-analysis to compare the two techniques regarding their outcomes.

Methods: A systemic computer-based search was carried out to find relevant articles. We searched the following databases: PubMed, Scopus, and Web of Science. The search was carried out from inception until April 2024 using the following search terms: "Transverse" OR "Mini-transverse" AND "Carpal tunnel syndrome" AND "Longitudinal." No filters were applied and reference lists of included papers were searched to try and include further relevant papers that were not identified during the search.

Results: The mini-transverse technique was associated with a lower functional status scale (FSS) and symptoms severity scale (SSS) compared to the longitudinal technique with mean difference [MD] of −0.32 (95% confidence interval [CI]: −0.52, −0.12, $P = 0.002$), and −0.43 (95% CI: −0.6, −0.25, $P < 0.00001$), respectively. Furthermore, the mini-transverse technique was associated with a lower pain score with MD of −0.5 (95% CI: −0.71, −0.3, $P < 0.00001$). Moreover, the time needed to return to work was statistically significantly lower in the mini-transverse group compared to the longitudinal group with an MD of −9.34 (95% CI: −13.55, −3.13, $P = 0.002$). No significant difference was observed between either group regarding the duration of operation (MD: −6.96, [95% CI: −16.66, 2.74, $P = 0.16$]) and the incidence of complications (odds ratio: 0.46, [95% CI: 0.15, 1.4, $P = 0.17$]).

Conclusion: The efficacy and safety outcome measures of the mini-transverse and longitudinal surgical approaches utilized on carpal tunnel syndrome patients were compared in the current study. Mini-transverse procedures yielded superior results in this study than longitudinal techniques, as they were statistically significant in relation to decreased FSS, SSS, pain score, and time required to return to work. However, in terms of the length of the procedure and the frequency of complications, both methods were similar.

Keywords: Carpal tunnel syndrome, Longitudinal, Mini-transverse, Hand surgical procedures, Minimally invasive surgical procedures

INTRODUCTION

The most prevalent upper limb entrapment neuropathy is carpal tunnel syndrome (CTS), which affects 0.6–3.4% of the general population and up to 5% of workers who regularly use their hands and wrists for daily tasks. Annually, there are 105 incidences of CTS for every 100,000 individuals.[14,15]

With a reported frequency of 6% in the general population, compression of the median nerve in the carpal tunnel is the most prevalent entrapment neuropathy of the upper limb.[5] It affects women more frequently.[2] Patients typically report excruciating paresthesias or a burning sensation in the radial half of their hand, which gets worse at night.[20] The majority of cases can be diagnosed with a competent clinical history, physical examination, and appropriately executed electrodiagnostic testing.[20] When conservative treatment is ineffective, the widely recognized surgical method for freeing the trapped median nerve in the carpal tunnel is the division of the transverse carpal ligament.[6] Historically, the literature has described three distinct surgical techniques: the endoscopic approach, the limited incision approach, and the classic or traditional open approach.[7] Classic open operations have gradually given way to minimally invasive procedures such as endoscopic carpal tunnel release and small incision treatments. A common criticism of the typical open carpal tunnel release is that it results in longer scars, more painful scars, unsightly wound healing, pillar pain, and a delayed return to work that lowers the quality of life.[12,21] To address the issues associated with open carpal tunnel release, a number of minimally invasive surgical techniques, including endoscopically assisted release, mini-open longitudinal, and mini-open transverse, have been developed.[8-23,32] When it comes to grip strength, pinch strength, and scar tenderness, endoscopic carpal tunnel releases have been demonstrated to be superior to open releases. However, the evidence is conflicting when it comes to symptom relief and going back to work.[32] It has been linked to a higher risk of irreversible nerve damage and inadequate flexor retinaculum release.[2,4,7,8,23]

Due to this gap and the controversy regarding whether to use the traditional open technique or the minimally invasive technique, we carried out this systematic review and meta-analysis to compare the two techniques regarding their outcomes.

MATERIALS AND METHODS

Search strategy

A systemic computer-based search was carried out to find relevant articles. We searched the following databases: PubMed, Scopus, and Web of Science. The search was carried out from inception until April 2024 using the following search terms: “Transverse” OR “Mini-transverse” AND “Carpal tunnel syndrome” AND “Longitudinal.” No filters were applied and reference lists of included papers were searched to try and include further relevant papers that were not identified during the search.

Inclusion and exclusion criteria

The following inclusion criteria were developed: studies comparing the use of mini-transverse techniques and longitudinal techniques in the surgical operation of carpal tunnel syndrome(CTS) patients, and the articles needed to be primary and present original data (not reviews or opinions) and articles of any language.

First, articles were screened by title and abstract by four independent authors in a blinded fashion. Articles that did not meet the inclusion criteria were excluded, and the first author settled any differences. Full texts of articles that met the inclusion criteria were retrieved and screened by two independent reviewers, and the first author settled conflicts.

Quality assessment

We assessed the quality of cohort studies using the New Castle Ottawa scale; studies with a score of 7–9 were of high quality, 4–6 were of moderate quality, and 1–3 were of low quality.[34] The risk of bias in randomized controlled trials was assessed using the Cochrane Risk of Bias 2 (ROB-2) tool.[23]

Data extraction and statistical analysis

Data were extracted from each study by two independent authors with conflicts settled by the first author. Extracted data included study design, sample size, and characteristics (age and sex). Furthermore, we collected the reported outcomes of the functional status scale (FSS), symptoms severity scale (SSS), pain scale, time to return to work, operation time, and complications.

Statistical analysis

We conducted the meta-analysis by pooling the results using Review Manager V. 5.4 software. A random effect model was utilized in pooling with a *P*-value of 0.05 and a confidence level of 95%. The analysis for dichotomous variables was done using event and total to calculate the odds ratio (OR), while that of continuous variables was done using mean difference (MD). Heterogeneity between studies was assessed using the I^2 statistical test. $P < 0.05$ was considered to be statistically significant.

RESULTS

Search strategy and screening

Our search strategy resulted in a total of 532; by duplicate removal, we screened 255 articles. After title and abstract screening, nine articles entered the full-text screening, resulting in a total of 6 articles[19,22,25,27,31,33] to be included in our meta-analysis [Figure 1].

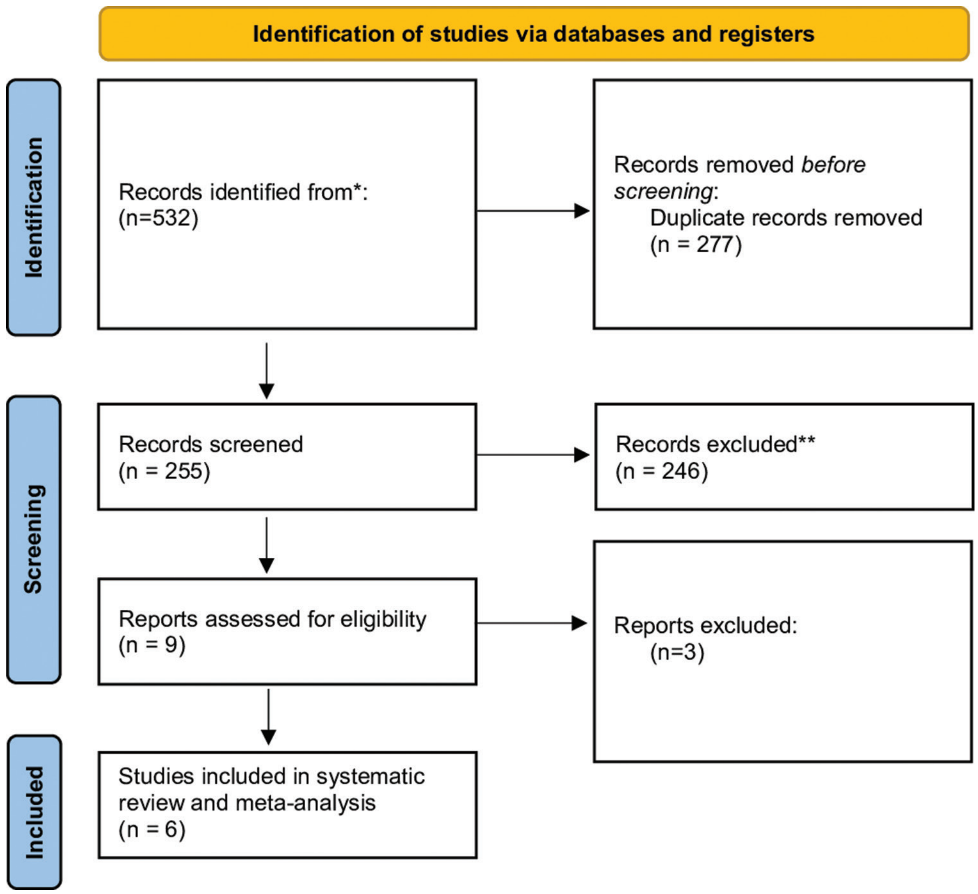

Figure 1: PRISMA flow diagram of database searching and screening. PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses. *Records identified from databases such as PubMed, Cochrane Library, and Web of Science. ** Records excluded based on predefined inclusion and exclusion criteria as described in the methods section.

Table 1: Baseline characteristics of the included studies.

Study ID	Design	Sample size		Age, mean (SD)		Gender (Male/Female)	
		Transverse	longitudinal	Transverse	longitudinal	Transverse	longitudinal
Tarallo *et al*. 2014[31]	RCT	60	60	63 (5)	65 (5)	30/30	30/30
Faraj *et al*. 2012[16]	RCT	20	20	37.2 (8.7)	41.0 (12.16)	NR	NR
Korkmaz *et al*. 2013[22]	Cohort	41	38	54 (11.8)	53 (11.8)	5,36	10,28
Oropeza-Duarte *et al*. 2021[27]	Cohort	8	9	46.3 (9)	48 (8)	1,7	1,8
Fazil *et al*. 2022[16]	Cohort	41	49	46 (9)	44 (7)	17/24	15/34
Wang *et al*. 2022[33]	Cohort	58	74	49.6 (11.8)	47.3 (13.5)	12,46	17,57

RCT: Randomized controlled trial, NR: Not reported,SD: Standard deviation

Quality assessment of included studies

Using NOS scale for cohort studies, three of the included studies were of high quality, and one of moderate quality [Table 1]. Regarding randomized controlled trials (RCTs) evaluated by ROB-2 tool,[28] the two studies were observed to have low risk of bias [Figure 2].

Baseline characteristics

Among the included studies, four were cohort studies, and two were RCTs with a total of 228 patients who underwent mini-transverse surgery and 250 patients who underwent longitudinal surgery. Baseline characteristics of the included articles are summarized in Table 2.

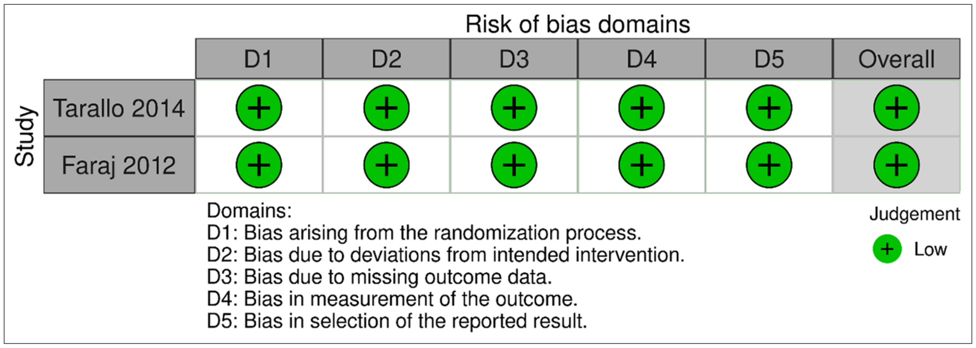

Figure 2: Risk of bias assessment of the randomized controlled trials using Rob-2 tool.

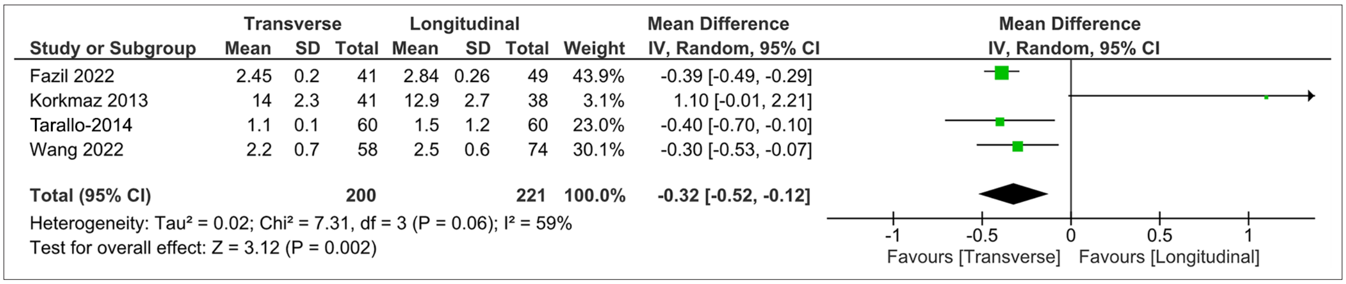

Figure 3: Comparison between mini-transverse and longitudinal techniques regarding functional status scale. SD: Standard deviation; CI: Confidence interval.

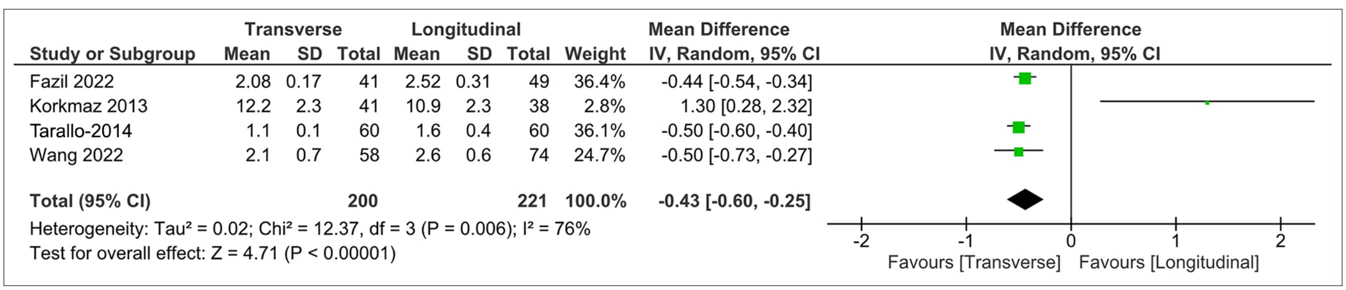

Figure 4: Comparison between mini-transverse and longitudinal techniques regarding functional status scale. SD: Standard deviation; CI: Confidence interval.

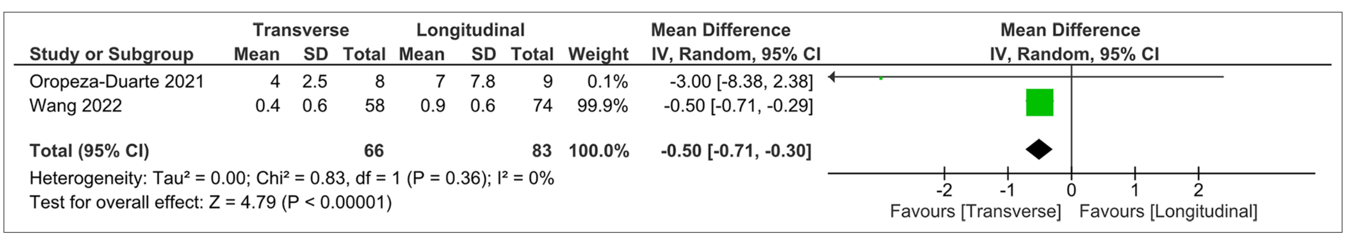

Figure 5: Comparison between mini-transverse and longitudinal techniques regarding pain. SD: Standard deviation; CI: Confidence interval.

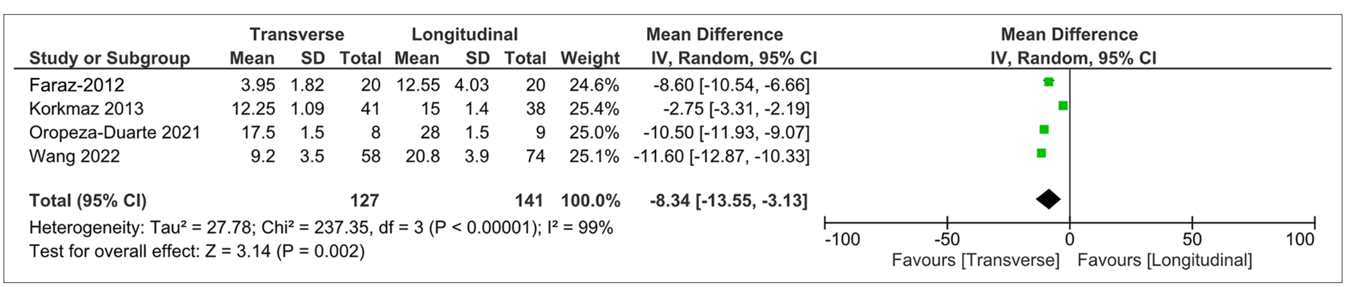

Figure 6: Comparison between mini-transverse and longitudinal techniques regarding time to return to work. SD: Standard deviation; CI: Confidence interval.

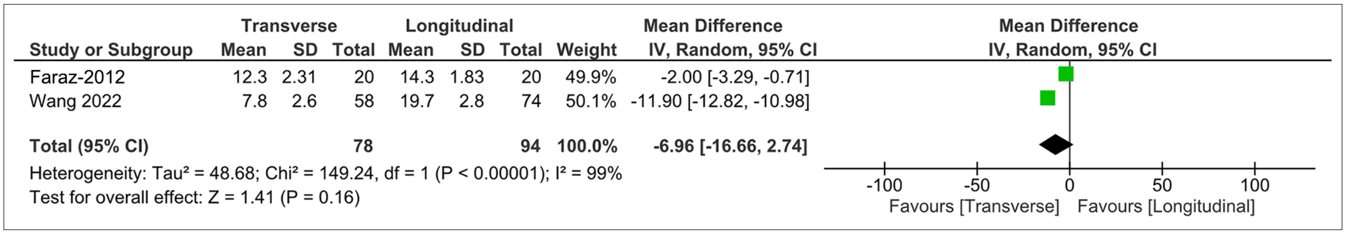

Figure 7: Comparison between mini-transverse and longitudinal techniques regarding time to return to work. SD: Standard deviation; CI: Confidence interval.

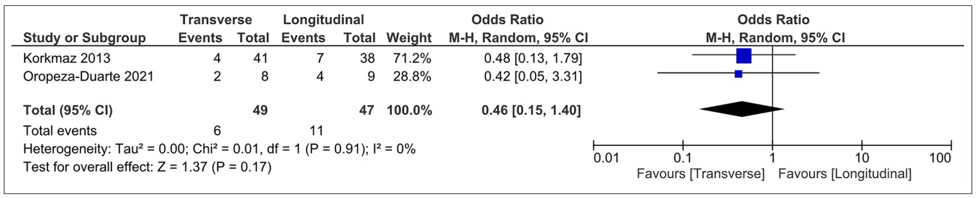

Figure 8: Comparison between mini-transverse and longitudinal techniques regarding complications. SD: Standard deviation; CI: Confidence interval.

Statistical analysis

The mini-transverse technique was associated with lower FSS, and SSS compared to the longitudinal technique with MD of −0.32 (95% CI: −0.52, −0.12, $P = 0.002$) and $I^2 = 59\%$, $P = 0.06$, and −0.43 (95% CI: −0.6, −0.25, $P < 0.00001$) and $I^2 = 76\%$, $P = 0.006$, respectively [Figures 3 and 4]. Furthermore, the mini-transverse technique was associated with a lower pain score with MD of −0.5 (95% CI: −0.71, −0.3, $P < 0.00001$) and $I^2 = 0\%$. [Figure 5].

Moreover, the time needed to return to work was statistically significantly lower in the mini-transverse group compared to the longitudinal group with MD of −9.34 (95% CI: −13.55, −3.13, $P = 0.002$) and $I^2 = 99\%$, $P < 0.00001$ [Figure 6].

No significant difference was observed between either group regarding the duration of operation (MD: −6.96, [95% CI: −16.66, 2.74, $P = 0.16$]) and the incidence of complications (OR: 0.46, [95% CI: 0.15, 1.4, $P = 0.17$]) [Figures 7 and 8].

DISCUSSION

The present study compared the efficacy and safety outcome measurements between the mini-transverse and longitudinal surgical techniques used in CTS patients. This study showed better outcomes obtained by mini-transverse techniques as they were statistically significantly associated with lower FSS, SSS, and pain score and needed less time to return to work compared with longitudinal techniques. On the other hand, both techniques were comparable regarding the duration of operation and the incidence of complications.

One very effective method for treating CTS is carpal tunnel decompression along with transverse carpal ligament division. Over the years, advances in carpal tunnel decompression surgery have been made to reduce surgical problems and side effects. For the release of the carpal tunnel, numerous techniques have been reported; these include the traditional open approach, the endoscopic approach, and, more recently, the limited incision approach.[3,24] Although each of the methods above has been linked to a number of issues and adverse effects, they have all been shown to be effective in reducing the symptoms of CTS.

The open release of the transverse carpal ligament is the traditional surgical method for treating CTS. While the surgeon can fully examine the transverse carpal ligament and contents of the carpal tunnel to rule out any secondary etiology, certain potential consequences come with it, including painful scarring, neurosensory impairments, and neuromas. Excellent outcomes have been seen in the treatment of CTS using open carpal tunnel release in the past few decades. It is now considered the gold standard for treating this condition. Nevertheless, according to other writers, the failure rate is between 7% and 20%.[10,19,27] In a traditional operation, a 4–5 cm longitudinal incision is made from Kaplan's cardinal line distally to beyond the wrist crease proximally. Today, most cases, however, are treated with a small longitudinal incision that finishes around 2–4 cm distal to the wrist crease.[29] The subcutaneous tissue, palmar fascia, mid-palmar fascia, transverse fibers, distal flexor retinaculum, forearm fascia, and transverse carpal ligament are all sectioned during both traditional and limited incision CTS release procedures. Nathan and associates conducted a comparison between carpal tunnel releases executed with incisions larger than 2.5 cm and those executed through

Table 2: Quality assessment of the included cohort studies using the New Caste Ottawa Scale.

Study name	Representativeness of the exposed cohort (☆)	Selection of the nonexposed cohort (☆)	Ascertainment of exposure (☆)	Demonstration that outcome of interest was not present at the start of the study (☆)	Comparability of cohorts based on the design or analysis (max☆☆)
Korkmaz *et al*. 2013[22]	☆	☆	☆	☆	☆
Oropeza-Duarte *et al*. 2021[27]	☆	-	☆	☆	☆
Fazil *et al*. 2022[25]	☆	-	☆	☆	☆☆
Wang *et al*. 2022[33]	☆	☆	☆		☆☆
Study name	**Assessment of outcome (☆)**	**Was follow-up long enough for outcomes to occur? (☆)**	**Adequacy of follow-up of cohorts (☆)**	**Quality level**	
Korkmaz *et al*. 2013[22]	☆	☆	☆	High	
Oropeza-Duarte *et al*. 2021[27]	☆	☆	-	Moderate	
Fazil *et al*. 2022[25]	☆	☆	-	High	
Wang *et al*. 2022[33]	☆	☆	☆	High	

smaller incisions. "The smaller the incision, the shorter the recovery period" was their conclusion.[26] Better results have been reported by numerous writers when using limited-incision techniques.[3,8,17]

With endoscopic CTS release, many of the problems associated with open CTS release can be avoided. According to Da Silva *et al*., it prevents damage to the unmyelinated nerve fibers at the interthenar crease that originate from the median nerve's palmar cutaneous branch and are located in the superficial, loose connective tissue between the palmar and flexor retinaculum. By keeping these branches intact, the formation of tiny neuromas – which may cause scar soreness following traditional open CTS release surgery – is prevented.[13] However, there are certain drawbacks of endoscopic CTS release surgery.[1,7] In their study of endoscopic CTS release in cadavers, Rowland and Kleinert found that in 38% of the cases, the flexor retinaculum had not fully released.[30] Furthermore, it has been noted that endoscopic CTS release is associated with a greater frequency of iatrogenic median nerve damage.[32] The procedure's higher overall costs and decreased attraction to general orthopedic surgeons can be attributed to the learning curve associated with endoscopic skills, longer operating times, and the requirement for additional specialized instruments.

With little to no difficulties, blind mini-open procedures have been carried out using a transverse wrist incision or a short longitudinal palmar incision.[3,8] Despite the fact that there are no appreciable variations in the medium- and long-term outcomes between open, mini-incision, and endoscopic operations, minimally invasive approaches enable a speedier return of hand function. The safety and efficacy of blind instruments were confirmed by Lee *et al*. study on 1332 Indiana Tome Carpal tunnel release procedures, which had an overall complication rate of 0.83%.[23] A case of minimally open carpal tunnel release with the Biomet Indiana Tome that resulted in full median nerve transection was documented.[9] Similar devices, the Safeguard System, consisting of a knife and a blunt guide are used to conduct miniopen blind carpal tunnel release.[17] Using an integrated light source, the KnifeLight device prevents vascular injury by improving blade location during flexor retinaculum division. Through a small transverse skin incision at the wrist, the carpal tunnel release is done blindly.[8,18] As opposed to a wrist incision with ligament division directed distally, Avci and Sayli preferred a palmar incision with ligament division directed proximally since it reduced the possibility of cutting the superficial palmar arch or partially releasing the transverse carpal ligament.[3]

To the best of our knowledge, this is the first meta-analysis comparing minimally invasive versus longitudinal approaches for CTS patients. However, the lack of included literature, especially RCTs, limits the current analysis. We, therefore, suggest carrying out additional RCTs to validate the current findings.

CONCLUSION

The efficacy and safety outcome measures of the mini-transverse and longitudinal surgical approaches utilized on CTS patients were compared in the current study. Mini-transverse procedures yielded superior results in this study than longitudinal techniques, as they were statistically significant in relation to decreased FSS, SSS, pain score, and time required to return to work. However, in terms of the length of the procedure and the frequency of complications, both methods were similar.

Ethical approval

The Institutional Review Board approval is not required.

Declaration of patient consent

Patient's consent was not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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