

Comparative study between tension band and compression screw fixation in metacarpophalangeal and proximal interphalangeal joint arthrodesis

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ABSTRACT

Introduction: Tension band wiring (TBW) and compression screw fixation are the most common methods used for proximal interphalangeal (PIP) and metacarpophalangeal (MCP) joint arthrodesis. The aim of this study was to compare outcomes between patients treated with those methods. **Materials and Methods:** A 10-year retrospective comparative study. The study population included skeletally mature patients treated for osteoarthritis or arthritis. Union rates, healing times, complications, and reoperation rates were compared between TBW and compression screw fixation methods. Outcomes were also studied in terms of rheumatic and nonrheumatic patients. **Results:** The study sample consisted of 56 cases and 44 patients (average age, 53 years). Group 1: 35 patients treated with TBW. Group 2: 21 patients treated with compression screw fixation. There were 32 rheumatic cases and 24 nonrheumatic cases. The average follow-up was 24 months. Union rates were 94,2% (Group 1) and 85,7% (Group 2). Complication rates were 11.4% (Group 1) and 23.8% (Group 2). Reoperation rates were 17.1% (Group 1) and 0% (Group 2). **Conclusions:** Both methods have high union rates; however, the nonunion incidence in the compression screw group was almost three times higher than in the TBW group. The reoperation rate was higher in the TBW group, mostly due to hardware removal. Healing time was shorter in non-rheumatic patients regardless of the method.

Key words: Arthrodesis; proximal interphalangeal and metacarpophalangeal joint fusion; tension band; compression screw.

Level of Evidence: III

Estudio comparativo entre banda de tensión y tornillo compresivo para la artrodesis interfalángica proximal y metacarpofalángica

RESUMEN

Introducción: Los métodos más utilizados para la artrodesis de la articulación interfalángica proximal y metacarpofalángica son la banda de tensión y el tornillo compresivo. El objetivo de este estudio fue comparar los resultados entre pacientes tratados con estas técnicas. **Materiales y Métodos:** Estudio comparativo retrospectivo de 10 años. Se incluyeron pacientes esqueléticamente maduros tratados por artrosis y artritis. Se analizaron la tasa de consolidación ósea, el tiempo hasta la consolidación, la incidencia de complicaciones y la tasa de reoperaciones. En un análisis secundario, se compararon los pacientes reumáticos y no reumáticos. **Resultados:** Se evaluaron 56 casos en 44 pacientes (edad promedio 53 años). Grupo 1: 35 casos tratados con banda de tensión y grupo 2: 21 tratados con tornillo compresivo. Había 32 casos reumáticos y 24 no reumáticos. El seguimiento promedio fue de 24 meses. La tasa promedio de consolidación fue del 94,2% en el grupo 1 y del 85,7% en el grupo 2. La incidencia de complicaciones fue del 11,4% en el primer grupo y 23,8% en el segundo, y la tasa de reoperaciones, del 17,1% y del 0%, respectivamente. **Conclusiones:** Ambos métodos permiten lograr tasas altas de consolidación, pero la incidencia de pseudoartrosis fue casi tres veces superior con el tornillo compresivo que con la banda de tensión. La tasa más alta de reoperaciones en el grupo con banda de tensión fue por extracción del material. El tiempo de consolidación fue más corto en los pacientes no reumáticos, independientemente de la técnica.

Palabras clave: Artrodesis; fusión interfalángica proximal y metacarpofalángica; banda de tensión; tornillo compresivo.

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INTRODUCTION

Several conditions may present with pain, deformity or instability in hand joints, with the most common being primary and secondary osteoarthritis and inflammatory conditions, such as rheumatoid arthritis. Although one of the main objectives of Orthopedics surgeons is to preserve hand joint mobility, following failure of conservative treatments, surgical options should be considered and presented to the patient. One of the most used surgical options is arthrodesis.¹⁻³

Arthrodesis remains the gold standard procedure for managing pain and achieving stability.⁴ The goal of joint fusion is to achieve adequate contact and compression between bones to allow for bone healing. A stable fixation allows early mobilization of adjacent joints, which prevents joint stiffness.⁵

There are several bone fixation methods, of which the most common are the TBW and the compression screw fixation methods.⁶⁻⁸ Both methods have been found to achieve adequate compression and stability, with good clinical and radiological outcomes⁹⁻¹⁸ TBWs procedures are less costly but have higher reported rates of hardware removal due to implant discomfort,^{7,9-13} while compression screw procedures are more costly but have a lower hardware removal rate.^{8,14-18}

Although there are biomechanical studies comparing stiffness associated with different joint fixation methods,¹⁹⁻²³ there are few published comparative clinical studies on the different hand joint fixation methods. There are even some comparative studies that evaluate arthrodesis methods that have been shown to produce less satisfactory outcomes, such as Kirschner wires.

The purpose of this study was to compare outcomes between PIP and MCP joint arthrodesis in patients treated with TBW and compression screw methods.

MATERIALS AND METHODS

We conducted a retrospective cohort study of 10 years to compare TBW and compression screw methods for PIP and MCP joint arthrodesis. The inclusion criteria were skeletally mature patients treated for primary or secondary osteoarthritis or arthritis, using PIP or MCP joint arthrodesis with the TBW or the compression screw method. The patients with no postoperative clinical or radiological follow-up were excluded. All surgeries were performed or directly supervised by experienced hand surgeons. Arthrodesis method selection was not random but determined by the criterion adopted by each surgeon for each specific case.

Data were collected from the electronic medical records. The analysis included demographics, causes of articular degeneration, affected fingers and joints, and fixation method. All patients were clinically and radiographically evaluated after surgery. Union rates, healing times, complications, and reoperation rates were compared between TBW and compression screw fixation methods.

In addition to the comparative analysis between patients undergoing TBW and compression screw procedures, outcomes were analyzed in terms of rheumatic and nonrheumatic patients, irrespective of the arthrodesis method used.

With respect to the surgical technique, all arthrodeses were performed through a dorsal approach. The articular cartilage of both bone surfaces was removed and repaired using the cup and cone method. Group-1 fixation was performed with two parallel Kirschner pins and a figure-of-eight wire loop. Group-2 fixation was performed with the antegrade passage of cannulated, compression screws. The number of screws (1 or 2) was determined for each case according to its particular requirements.

Achieving adequate digit rotation, and contact and compression between bones was always a main concern.

The postoperative evaluation in all patients consisted of periodic clinical and radiological control follow-ups. Anteroposterior and lateral radiographs of the affected finger were collected until they evidenced bone union.

An independent author who was not involved in the surgical management studied the postoperative radiographs to establish bone union and time to successful fusion. Bone union was defined by the presence of bone trabeculae crossing the fusion site in more than 50% of that area. Delayed union was defined by bone union occurring at postoperative week 12 or later. Postoperative complication occurrences and the need for reoperation were studied using the data collected from the electronic medical records.

Statistical analysis

We conducted a descriptive statistical analysis. Categorical variables are described as absolute and relative values (percentages). Continuous variables were described as measures of central location (mean) and measures of spread (range and standard deviation).

RESULTS

Inclusion criteria considered cases within 10 years, from August 2008 to August 2018, and was met by 60 cases, 47 patients. The final study sample was comprised of 56 cases, 44 patients (22 males and 22 females) averaging 53 years (range, 17-79), as 4 were lost to follow-up. Thirty-five cases (62.5%) had been treated with TBW as fixation method and 21 (37.5%) with compression screw. The average follow-up was 24 months (range, 6-100). Arthrodesis indications were due to rheumatic conditions in 32 cases (57%) and to nonrheumatic conditions in 24 cases (43%). Rheumatic cases were comprised of 26 cases of rheumatoid arthritis, 3 psoriatic arthritis, 2 juvenile idiopathic arthritis, and 1 Still's disease. Nonrheumatic cases: primary osteoarthritis (2 cases), post-traumatic osteoarthritis (11 cases), chronic instability (6 cases), and five other causes (shortening arthrodesis in Dupuytren's patient [1 case], sequela of a flexor tendon lesion [1 case], ulnar paralysis [1 case], spastic thumb-in-palm deformity [2 cases]). The study sample consisted of 18 (32%) PIP arthrodeses and 38 (68%) MCP arthrodeses. PIP arthrodeses involved the index (2 cases), the middle (2 cases), the ring (cases), and the little finger (10 cases).

All MCP procedures were thumb arthrodeses except for one case of little finger arthrodesis. The overall distribution of operated digit was: thumb, 37 cases (66%); index finger, 2 cases (3.5%); middle finger, 2 cases (3.5%); ring finger, 4 cases, (7%); little finger, 11 cases, (20%) (Table 1).

Bone union was achieved by 33 of the 35 Group-1 patients (94.2%), with an average time to bone healing of 6.4 weeks (range, 4-12) (Figure 1), and by 18 of the 21 Group-2 patients (85.7%), with an average time of 7.2 weeks (range, 4-15) (Figure 2). Complications were experienced by 4 of the 35 Group-1 patients (11.4%) and 5 of the 21 Group-2 patients (23.8%). Reoperations were performed in 6 of the 35 Group-1 patients (17.1%) while no Group-2 patients required reoperation (0%) (Table 2).

Bone union was achieved by 29 of the 32 rheumatic patients (90.6%), with an average time to bone healing of 7.2 weeks (range, 4-15), and by 22 of the 24 nonrheumatic patients (91.6%), with an average time of 6 weeks (range, 4-12). Complications were experienced by 6 of the 32 rheumatic patients (18.7%) and 3 of the 24 nonrheumatic patients (12.5%). Reoperations were performed in 2 of the 32 rheumatic patients (6.2%) and in 4 of the 24 nonrheumatic patients (16.6%) (Table 3).

Group-1 complications included 2 cases of pseudarthrosis, 1 case of delayed bone healing, and 1 case of extensor pollicis longus tendon rupture. One case of pseudarthrosis involved a nonrheumatic patient who underwent arthrodesis revision surgery and conversion to plate fixation with bone autograft and eventually achieved bone union. The other case involved a rheumatic patient who remained asymptomatic and required no further surgical intervention. Both cases involved atrophic pseudarthroses. One nonrheumatic patient had delayed bone healing (at postoperative week 12).

One rheumatic patient suffered from a tendon rupture 6 weeks after surgery and was successfully treated with hardware removal and extensor indicis proprius tendon transfer. Group-2 complications included 3 pseudarthrosis cases and 2 delayed bone healing cases. One case of pseudarthrosis involved a nonrheumatic patient who refused to undergo revision surgery while the other two cases involved rheumatic patients who remained asymptomatic and so required no further surgeries. All cases involved atrophic pseudarthroses (Figure 3). Both delayed bone healing involved rheumatic patients and bone union was achieved 14 and 15 weeks after surgery. The available data showed no other complications, such as intraoperative infections or fractures.

All reoperations were performed in Group-2 patients, 6 cases (2 rheumatic patients, 4 nonrheumatic patients). Hardware removal was performed in 4 patients due to material intolerance. The remaining 2 reoperations were arthrodesis revision due to pseudarthrosis and tendon transfer due to tendon rupture.

Table 1. Demographics

Variables	Tension band	Compression screw
Number of cases	35	21
Age, years (range)	52.8 (17-79)	54,1 (24-69)
Males (%)	18 (58.0)	4 (28.5)
Rheumatic patients	14 (40.0)	18 (85.7)
Follow-up, months (range)	28.1 (6-100)	18,3 (6-43)
Joints		
Proximal interphalangeal	13	5
Metacarpophalangeal	22	16
Fingers		
Thumb	22	15
Index	1	1
Middle	1	1
Ring	3	1
Little	8	3
Indication		
Primary osteoarthritis	2	0
Post-traumatic osteoarthritis	11	0
Chronic instability	5	1
Other causes	3	2
Rheumatoid arthritis	8	18
Psoriatic arthritis	3	0
Juvenile idiopathic arthritis	2	0
Still's disease	1	0

DISCUSSION

PIP and MCP arthrodesis is widely used to improve the hand function in patients with severe primary and secondary osteoarthritis or with rheumatic disease because it helps allows to resolve pain and joint instability and to achieve a functional position of fingers. Fixation methods have changed in the past decades because of the advent of new technology and research that made possible the development of implants allowing for more reliable fixations and early mobilization of adjacent joints. However, such developments have in parallel introduced new technical complications and challenges that must be considered.²⁶

TBW and compression screws are the two most widely used methods used in joint arthrodeses and have been shown to achieve adequate compression and stability, with good clinical and radiological outcomes. TBW advantages include being less costly, readily available and allowing bone-surface compression at the arthrodesis site to occur during active motion; However, TBW has higher reported rates of hardware removal due to implant discomfort. On the other hand, the compression screw has a lower hardware removal rate and, according to some studies, potential lower pseudarthrosis rate.²⁵ This method disadvantages are its higher cost and some constraints



Figure 1. A and B. Proximal interphalangeal post-traumatic osteoarthritis of the ring finger in a 63-year-old male. C and D. Arthrodesis with tension band at postoperative month-6 control.



Figure 2. A and B. Metacarpophalangeal joint of the thumb involvement in a 61-year-old female with rheumatoid arthritis. C and D. Arthrodesis with compression screw at first postoperative year control.

Table 2. Comparative results between the surgical techniques

Variables	Tension band	Compression screw
Union rate		
n/total (%)	33/35 (94.2)	18/21 (85.7)
Time to bone healing		
Weeks (SD)	6.4 (2.0)	7.2 (2.7)
Complication rate		
Patients (%)	4/35 (11.4)	5/21 (23.8)
Pseudarthrosis (%)	2/35 (5.7)	3/21 (14.2)
Delayed union (%)	1/35 (2.8)	2/21 (9.5)
Tendon rupture	1/35 (2.8)	0/21 (0)
Reoperation rate		
Patients (%)	6/35 (17.1)	0/21 (0)
Hardware removal (%)	4/35 (11.4)	0/21 (0)
Arthrodesis revision (%)	1/35 (2.8)	0/21 (0)
Tendon transfer (%)	1/35 (2.8)	0/21 (0)

SD, standard deviation

Table 3. Comparative results between rheumatic and nonrheumatic patients

Variables	Rheumatic patients	Nonrheumatic patients
Union rate		
n/total (%)	29/32 (90.6)	22/24 (91.6)
Time to bone healing		
Weeks (SD)	7.2 (2.3)	6.0 (2.1)
Complication rate		
Patients (%)	6/32 (18.7)	3/24 (12.5)
Pseudarthrosis (%)	3/32 (9.3)	2/24 (8.3)
Delayed union (%)	2/32 (6.2)	1/24 (4.1)
Tendon rupture	1/32 (3.1)	0/24 (0)
Reoperation rate		
Patients (%)	2/32 (6.2)	4/24 (16.6)
Hardware removal (%)	1/32 (3.1)	3/24 (12.5)
Arthrodesis revision (%)	0/32 (0)	1/24 (4.1)
Tendon transfer (%)	1/32 (3.1)	0/24 (0)

SD, standard deviation



Figure 3. **A and B.** Metacarpophalangeal joint of the thumb involvement in a 59-year-old female with rheumatoid arthritis. **C and D.** Atrophic pseudarthrosis after compression screw arthrodesis at postoperative month-18 control.

associated with achieving the expected fixation angle due to the degree of flexion in which the joint can be placed, which, although has benefited from the development of cannulated screws, still remains more limited than the flexion degree provided by TBWs.²⁶

Multiple studies reporting TBW good results have been published. Stern *et al.*¹² reported a series of 290 arthrodeses in 203 patients using TBW for their PIP and MCP joint arthrodeses, with a 97% union rate and a 9% hardware removal rate. In a retrospective study of 76 TBW arthrodesis cases in 63 patients, Uhl and Schneider¹³ reported a 99% union rate and 10 patients requiring hardware removal. Khuri¹¹ reported bone union in all his cases from a TBW arthrodesis series consisting of 5 MCP and 10 PIP arthrodeses, with four cases requiring hardware removal. In a recent study conducted by Hohendorff *et al.*,¹⁰ which consisted of 15 patients with PIP TBW arthrodeses, patients achieved bone union and were very satisfied with the procedure outcome, which did not affect their activities of daily living.

Meanwhile, several studies have reported satisfactory results using compression screws as hand joint fixation method. Ayres *et al.*¹⁵ reported, in their series of 51 PIP arthrodeses using compression screws, a 98% union rate, and a 4% hardware removal rate. Katzman *et al.*¹⁶ also reported good results in their series of 51 interphalangeal joint arthrodeses, with all patients achieving bone union and none requiring hardware removal. Likewise, Teoh *et al.*¹⁸ reported a 96% union rate and no cases of hardware removal in 23 interphalangeal joints treated with compression screws, of which 9 were PIP cases.

However, despite the wide use of arthrodesis as a salvage procedure in hand surgery, only a limited number of comparative studies on the different fixation methods have been published. In their retrospective study, Ijsselstein *et al.*²⁴ compared the results of Kirschner wire and TBW fixations used in MCP and interphalangeal arthrodesis and reported significantly higher rates of infection and rearthrodesis in patients treated only with Kirschner wire. Leibovic and Strickland²⁵ published a comparative retrospective analysis on the use of several PIP arthrodesis methods in 224 cases. The lowest pseudarthrosis rate corresponded to the Herbert screw method; the intermediate rate to the TBW method; and the highest rate to the Kirschner wire method. Breyer *et al.*⁵ conducted a comparative retrospective study between the TBW and compression screw methods for the arthrodesis of the MCP, PIP, and thumb interphalangeal joints, and reported that both methods had similar outcomes related to union rates, healing time, and complication rate, but that TBW patients had a higher reoperation rate due mostly to hardware removal.

Our study series results show that, although union rates were high in both the TBW and the compression screw groups (94.2% and 85.7%, respectively), the pseudarthrosis rate in the compression screw group was 14.2%, approximately three times higher than the TBW pseudarthrosis rate (5.7%). We found no differences between both groups in terms of healing time. The complication rate in the compression screw group was close to 25%, with all of the complication cases associated with disturbances in bone union; in contrast, the TBW complication rate was 11.4%. Reoperations in our series were only performed in TBW patients, in most cases due to hardware removal. However, there is no adequate data to assess the evolution and prognosis of pseudarthrosis patients of the compression screw groups as they may have undergone reoperation after the study period.

Postoperative outcomes were satisfactory and similar to those reported by Breyer *et al.*,⁵ who to the best of our knowledge, have conducted the only similar study that has been published to date. Both studies' number of patients and postoperative follow-up periods are similar. Our series union rate was 94.2% in the TBW groups and 85.7% in the compression screw group, which are similar to the values reported by Breyer *et al.*⁵ (92.9% and 87.5%, respectively). Our series average time to bone healing was 6.4 weeks in the TBW group and 7.2 weeks in the compression screw group, which are lower than those reported by Breyer *et al.*⁵ (9.4 and 9.8 weeks, respectively). Our series compression rate was 11.4% in the TBW group and 23.8% weeks in the compression screw group, which are lower than those reported by Breyer *et al.*⁵ (28.6% and 27.6%, respectively).

There were 5 pseudarthrosis cases out of the 56 study cases of our series (8.9%), with a pseudarthrosis rate of 5.7% in the TBW groups and of 14.2% in the compression screw group, which are consistent with the literature expected pseudarthrosis rate (0-15% in PIP arthrodeses, and 0-20% in thumb MCP arthrodeses)²⁷ and similar to the values reported by Breyer *et al.*⁵ (7.1% in TBW patients, and 14.2% in compression-screw patients). In our series, there was another complication: a case involving extensor pollicis longus tendon rupture at month 6 after a thumb MCP arthrodesis with the TBW method. Stanley *et al.*²⁸ had also reported this complication in two cases from their series of 42 thumb MCP arthrodeses with the Kirschner wire method. Six of the 35 TBW patients of our series (17.1%) required reoperation while no compression-screw patient required reoperation. Hardware removal was due to material intolerance in 4 of the TBW patients (11.4%). The published hardware removal rates in TBW patients include: 9%, Stern *et al.*;¹² 13% Uhl and Schneider;¹³ 26%, Khuri;¹¹ and 25%, Breyer *et al.*⁵ Hardware removal rates in compression-screw series range from 0% to 4%.^{5,15,16,18}

Our series analysis in terms of rheumatic-nonrheumatic patients showed shorter healing times in nonrheumatic patients, irrespective of the used method, with no other significant difference in the postoperative outcomes.

The main limitations of this study include: its retrospective nature, small sample size, and non-randomized method of treatment selection. The strengths of this study include: the limited number of similar comparative studies on these methods and the even fewer studies comparing these methods outcomes in terms of rheumatic-nonrheumatic patients.

CONCLUSIONS

The results of this comparative study show that both the TBW method and the compression screw method for PIP and MCP arthrodeses have high union rates. However, it should be noticed that the pseudarthrosis rate in the compression screw group was approximately three times higher than the TBW pseudarthrosis rate. We found no differences between both methods in terms of healing time. Almost a quarter of the compression screw patients had complications and all of them were associated with disturbances in bone union while the complication rate in TBW patients was significantly lower. Reoperations were only performed in TBW patients, mostly due to hardware removal. However, there is no adequate data to assess the evolution and prognosis of pseudarthrosis patients of the compression screw groups as they may have undergone reoperation after the study period.

Finally, nonrheumatic patients had shorter healing times, irrespective of the used method, than rheumatic patients, with no other significant difference in the postoperative outcomes between rheumatic-nonrheumatic patients.

Conflict of interests: The authors claim they do not have any conflict of interest.

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