

Comparative study between bouquet technique and transverse wires in management of unstable metacarpal fractures

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Abstract:

Background: Frequent hand trauma is accompanied by many metacarpal and phalangeal fractures. Metacarpal fractures represent 18 to 44% of all hand fractures. About 88 percent of all metacarpal fractures involve metacarpals other than the thumb, with the fifth finger being the most commonly afflicted. The majority of metacarpal fractures occur in active and working populations, particularly adolescents and young adults, and are often caused by a direct blow, crushing, or projectile. **Methods:** This prospective study was carried out in Benha university hospital on 20 patients with unstable 2nd to 5th metacarpal fractures: 10 fixed by intramedullary k-wires (Bouquet osteosynthesis), 10 fixed with transverse wiring. **Conclusion:** Transverse wires are versatile, easily accessible, affordable, and surgeon-friendly compared to the bouquet method. They provide a suitable range of motion, enough grip strength, and a functionally favorable result overall. We urge more prospective clinical trials to give a strong guideline for selecting an appropriate surgical method for the fixation of a metacarpal fracture and evaluating the functional outcomes.

Keywords: bouquet technique, transverse wires, metacarpal fractures.

1. Introduction

Hand injuries are very common resulting frequently in metacarpal and phalangeal fractures (2). Metacarpal fractures represent 18 to 44% of all hand fractures. About 88% of all metacarpal fractures involve metacarpals other than the thumb, with the fifth finger being the most commonly afflicted. The majority of metacarpal fractures occur in active and working populations, particularly adolescents and young adults, and are often caused by a direct blow, crushing, or projectile. (3)

The great majority of hand fractures are stable before or during closed reduction and may be treated satisfactorily with closed procedures. Multiple fractures, severe shortening, rotational distortion, or considerable angular deformity may need surgical treatment for non-operatively treated metacarpal and phalangeal fractures. Fracture stabilization options vary dependent on fracture type, surgeon preference, and severity of associated injuries. (4)

Appropriate treatment includes an appropriate evaluation, a physical examination, and imaging. This method should yield a rehabilitation strategy that prioritizes osseous, articular, and soft tissue components (3). Numerous surgical procedures have been described for the treatment of metacarpal shaft fractures, but there is no consensus regarding the most effective procedure. Open reduction internal fixation, Kirschner (K-) wire fixation, suture fixation, and cerclage wiring are available options. (5)

Bouquet osteosynthesis (multiple intramedullary flexible wires for the fixation of metacarpal fractures) was first described by

Foucher and has had great results over the past several decades. This technique employs an open approach anterograde intramedullary fixation with three pre-bent Kirschner wires (K-wires) placed into the reduced metacarpal head in divergent orientations. (6)

With minimally invasive methods employing Kirschner wires, it is possible to avoid extensive surgical dissection and devitalization of soft tissue at the fracture site. In addition, it decreases the likelihood of extensor tenosynovitis, which has been associated with K-wire fixation. (5)

The downsides of the wire approach include a lack of total stability, wire migration, pin site issues, infection and the need for implant removal, extensor tenosynovitis, and sensory abnormalities. (7)

2. Patients and Methods

This prospective study was held in Benha university hospital including 20 patients with unstable 2nd to 5th metacarpal fractures: 10 fixed by intramedullary k-wires (Bouquet osteosynthesis), 10 fixed with transverse wiring.

Written consent was obtained and the patients was informed about the surgical procedure. All the patients were followed up for a minimum period of 8 weeks and the maximum period of follow up was 16 weeks. These patients were assessed clinically by measuring the total active motion (sum of the range of motions of the metacarpophalangeal and interphalangeal joints), together with grip strength, and the results were recorded. Fracture union was confirmed radiologically.

Inclusion criteria were (Irreducible or unstable fracture, Isolated or multiple shaft metacarpal fractures, Angulation of the fracture greater than 30 degrees, Rotational deformity greater than 10 degrees, Gross (>5mm) shorting of the metacarpal. Exclusion criteria were (Patient with non-united metacarpal fractures, old fracture, Intra-articular metacarpal fracture). All patients underwent proper history taking, physical examination, radiological evaluation.

Operative steps of bouquet technique:

To get access to the canal, a 2-cm arciform incision is made proximal to the metacarpal base, followed by a hole drilled distally into the ulnar cortex. Using traditional treatments, such as traction and fracture manipulation, or the Jahss maneuver for neck fractures, the metacarpal fracture was decreased. Percutaneous reduction clamps may be used to reduce the anatomical size of fractures such as spiral fractures. After reduction is confirmed using an image intensifier and percutaneous fixation with two round-tip K-wires (0.8 mm) is conducted, the first K-wire is bent at one end to regulate the direction of introduction and gently curved along its length before being pushed into the medulla with a T-handle.

After repeatedly inserting the two wires into the medullary canal, they are positioned in different orientations to create a "flower bouquet" in the metacarpal head. The K-wires were subsequently buried beneath the skin following the completion of final fluoroscopic checks (Fig. 34 A, B, C) and clinical tests for the rotational position of the finger in an extended and semi-flexed posture. To enhance soft tissue repair, a short arm splint was put in an intrinsic plus position (80° metacarpophalangeal joint flexion and full interphalangeal joint extension) for fourteen days.

Operative steps of transverse wiring:

Patient placed in the supine position with hand-on-hand table, the patient underwent general or local anesthesia. Flex the Metacarpophalangeal joint to obtain control of the distal fragment. The displaced metacarpal fracture was reduced by traction and direct reduction and maintain reduction by reduction clamp. Under fluoroscopic control, smooth k.wire inserted proximal to fracture and not too far. Abductor digit minimi muscle was pushed palmar ward before inserting of k.wire to prevent tethering of muscle. K.wire links the fifth and fourth metacarpals by transversely traversing four cortices (two cortex of fractured metacarpal and two cortex of adjacent metacarpal). Pass a second transverse k.wire distal to the fracture site, and maybe

more than two k.wires based on the stability of the reduction. Using a fluoroscope, inspect the wire and reduction. The k. wire was then bent and stored for eventual removal.

Follow up program:

Early follow up (6 weeks)

The hand is placed in an intrinsic plus position splint (80° metacarpophalangeal joint flexion and full interphalangeal joint extension) to avoid tightening of the collateral ligaments and digital stiffness for 14 days postoperative. After removal of the splint, patient is encouraged to begin active protected ROM. The surgical stabilization enables such early range of motion of the hand to avoid stiffness without the risk of secondary displacement, allowing the patient to reach near range of motion in the metacarpophalangeal and interphalangeal joints before removal of the wires. Patient discharged from the hospital in the next day following the operation, first visit in the outpatient clinic was one week next discharge from the hospital for dressing, second visit 2 weeks following the discharge from the hospital for imaging, dressing and start active protected range of motion of the MCP and IP joints. K-wires were removed 6-10 weeks after the surgery, patients were evaluated clinically on weeks 2,4,6 after surgery with x-ray assessment using an anteroposterior, lateral and oblique views on 2,4,6 weeks.

Late follow up (6 weeks to 3 months)

The patients were evaluated clinically and radiologically with hand lateral, posteroanterior and oblique X-rays on weeks 8,10,12 weeks after surgery. Subjective evaluation consisted of recording pain using VAS (visual analog scale) and limitation of daily activities using (Quick DASH score).

Ethical considerations:

Approval of the study protocol by ethical scientific committee of Benha university hospital was obtained & informed consent was obtained from the parents before enrollment in the study.

Data Collection and Analysis:

The acquired data was edited, coded, tabulated, and uploaded to a computer using IBM's 2017-released Statistical program for Social Science. IBM SPSS Statistics for Windows, Version 25.0 (Armonk, New York: IBM Corporation, 2005). According to the type of data acquired for each parameter, the results were displayed and analyzed accordingly.

- Descriptive statistics:
- Mean, Standard deviation (\pm SD), minimum and maximum for parametric numerical data.

- Frequency and percentage of non-numerical data.
- Charts
- Column and bar charts were used to create visual presentations of means or percentages. They were displayed in vertical and horizontal columns.
- Probability of results

A *p* value is considered significant if less than 0.05.

3. Results

The present study was conducted on 20 cases. Their mean age was 31.6 years, ranged from 15 to 52 years. They were 17 males (85%) and 3 females (15%) (Table 5, figure 41).

Regarding the mechanism of injury, 75% had punch trauma, 15% fell from height and 10% had RTA.

The mean duration of surgery of Bouquet technique was 27.5 minutes, ranged 20 to 40 minutes. While the mean duration of surgery of Transverse wires was 21.4 minutes, ranged 16 to 32 minutes, with significantly shorter duration of surgery belonged to TW. Mean wire removal duration was 8.5 after Bouquet technique, ranged from 8 to 9 weeks, while Mean wire removal duration was 6.2 after Transverse wires, ranged from 6 to 8 weeks. Bouquet technique showed significantly longer duration of wire removal (table 10, figures 47-48).

Regarding Bouquet technique, moderate pain was found in 20%, mild pain in 39%, mean pain score was 0.7, ranged from 0 to 2; while Transverse wires, moderate pain was found in 30%, mild pain in 39%, mean pain score was 0.9, ranged from 0 to 2; with no significant differences between both groups regarding pain intensity (table 11).

Regarding Bouquet technique, total percentage of active ROM value was recorded which revealed that, (85°) was (10 %), (88°) was (10 %), (90°) was (30%), (93°) was (10%), (95°) was (20%), (99°) was (20%). The mean and range of active ROM was 92.4° (85°-99°).

Regarding Transverse wires, the total percentage of active ROM value was recorded which revealed that, (85°) was (10 %), (88°) was (10 %), (90°) was (20%), (95°) was (40%), (99°) was (20%). The mean and range of active ROM was 93.1° (85°-99°).

Regarding Bouquet technique, total percentage of passive ROM value was recorded which revealed that, (95°) was (10 %), (98°) was (30 %), (99°) was (30%), (100°) was (30%). Mean and range of active ROM was 98.6° (95°-100°).

Regarding Transverse wires, total percentage of passive ROM value was recorded which revealed that, (95°) was (10 %), (98°) was (10 %), (99°) was (50%), (100°) was (30%). Mean and range of active ROM was 98.8° (95°-100°).

Grip strength was evaluated during this study which revealed that in Bouquet technique group; mean proportion of dominant grip strength was 96.9%, and in Transverse wires, mean proportion of dominant grip strength was 97.1%. There was non-significant differences between both groups as *p* value >0.05 (table 14).

Grip strength was evaluated during this study which revealed that in Bouquet technique group, mean proportion of non-dominant grip strength was 97.5%, and in Transverse wires, mean proportion of non-dominant grip strength was 96%. There was non-significant differences between both groups (*P*-value >0.05 (table 15).

Quick Dash Score was estimated during this study which revealed that mean Dash score was 1.2 in Bouquet technique, ranged from 0 to 3; while in Transverse wires, mean Dash score was 2.3 and ranged from 0 to 3.

Mean TAM in Bouquet technique was 260.1, ranged from 250 to 270; while in Transverse wires, was 259.5, was 250 to 275 (table 17).

Union outcome was evaluated within this study in relation to total percentage of each time interval was recorded within this study, which revealed that in Bouquet technique: 6 weeks, was (10%), 7 weeks was (40%), 8 weeks was related to (50%) with mean (\pm SD) time of union was 7.4 (\pm 0.7) weeks. While in Transverse wires: 6 weeks, was (40%), 7 weeks was (40%), 8 weeks was related to (20%) with mean (\pm SD) time of union was 6.8 (\pm 0.8) weeks. With significant association of Transverse wires technique with rapid union when compared to Bouquet technique (table 18, figure 50).

All studied cases had no complications. Removal of wires require re-operation in 50% of Bouquet technique, but not Transverse wires (table 19).

4. Discussion

The majority of hand fractures are stable prior to or during closed reduction and can be treated well using closed procedures. Multiple fractures, significant shortening, rotational deformity, and extreme angular deformity may necessitate surgical intervention. The choice of fixation is determined by the fracture pattern, the surgeon's preference, and the existence of other lesions (64).

Numerous surgical techniques have been documented for the treatment of metacarpal shaft fractures, however there is no consensus about the most effective procedure. Open reduction internal fixation, Kirschner (K-) wire fixation, suture fixation, and cerclage wiring are available options. It is remarkable because bouquet osteosynthesis eliminates the necessity for considerable surgical dissection and devitalization at the fracture site. It also reduces the occurrence of extensor tenosynovitis by avoiding dorsal plate-induced extensor irritation (65).

So, the current work compared between the clinical and radiological results of bouquet technique and transverse wires in the management of unstable metacarpal fractures.

This study was prospective randomized study conducted on 20 adult patients with metacarpal fractures recruited from the orthopedic outpatient clinic of Benha University hospital, Cairo, Egypt.

The patients were divided into two groups, Group I which included 10 patients will be treated by bouquet technique, and Group II, which included 10 patients will be treated by transverse wires.

Regarding results of other researches compared to our result:

Our study showed that, mean duration of surgery of Bouquet technique was 27.5 minutes, ranged 20 to 40 minutes. While the mean duration of surgery of Transverse wires was 21.4 minutes, ranged 16 to 32 minutes, with significantly shorter duration of surgery belonged to TW. Mean wire removal duration was 8.5 after Bouquet technique, ranged from 8 to 9 weeks, while Mean wire removal duration was 6.2 after Transverse wires, ranged from 6 to 8 weeks. Bouquet technique showed significantly longer duration of wire removal.

While Adawy et al., 2022 showed that the mean operative time of bouquet technique in their study was 26.5(\pm 7.797) minutes (66). And in 2018, Rocchi et al. revealed their findings on 150 patients treated with antegrade intramedullary K-wires for metacarpal fracture fixation; the mean time of surgery was 14 minutes (range: 4–60), corroborating our findings that TW was quicker than Bouquet technique (71).

Regarding Bouquet technique, moderate pain was found in 20%, mild pain in 39%, mean pain score was 0.7, ranged from 0 to 2; while Transverse wires, moderate pain was found in 30%, mild pain in 39%, mean pain score was 0.9, ranged from 0 to 2; with no significant differences between both groups regarding pain intensity.

Regarding Bouquet technique in our study, total percentage of active ROM value was recorded which revealed that, (85°) was (10 %), (88°) was (10 %), (90°) was (30%), (93°) was (10%), (95°) was (20%), (99°) was (20%). Mean and range of active ROM was 92.4° (85°-99°), and total percentage of passive ROM value was recorded which revealed that, (95°) was (10 %), (98°) was (30 %), (99°) was (30%), (100°) was (30%). Mean and range of active ROM was 98.6° (95°-100°). Regarding Transverse wires, total percentage of active ROM value was recorded which revealed that, (85°) was (10 %), (88°) was (10 %), (90°) was (20%), (95°) was (40%), (99°) was (20%). Mean and range of active ROM was 93.1° (85°-99°) and total percentage of passive ROM value was recorded which revealed that, (95°) was (10 %), (98°) was (10 %), (99°) was (50%), (100°) was (30%). Mean and range of active ROM was 98.8° (95°-100°) with no significant differences were found between both techniques regarding active and passive ROM.

In the 2015 trial, bouquet pinning was administered to 41 patients with unstable metacarpal fractures. The mean TAM was 260o and the mean grip strength was 49 kg. The total VAS satisfaction (0-100, 100 being the highest) was 100 and the mean Quick DASH score (0-100, 0 being the highest) ranged from 0 to 0. (0 - 41). Only two individuals got superficial pin tract infections, which were treated orally with antibiotics, and two patients experienced pin movement. At 1 year follow-up, 4 patients exhibited slight rotational distortion, but it did not affect the functional result and did not require surgical intervention (72).

Regarding Union outcome in our study in relation to total percentage of each time interval was recorded within this study, which revealed that in Bouquet technique: 6 weeks, was (10%), 7 weeks was (40%), 8 weeks was related to (50%) with mean (\pm SD) time of union was 7.4 (\pm 0.7) weeks. While in Transverse wires: 6 weeks, was (40%), 7 weeks was (40%), 8 weeks was related to (20%) with mean (\pm SD) time of union was 6.8 (\pm 0.8) weeks. With significant association of Transverse wires technique with rapid union when compared to Bouquet technique.

While Rocchi et al., 2018, who published data on more than 150 patients, noted rotational deformity in eight individuals, twelve patients experienced a superficial pin site infection/inflammation that healed with oral antibiotic therapy (71).

In 2012, a comparison was made between intramedullary (Bouquets) pinning and low-

profile plate fixation in 30 patients with metacarpal fractures. 15 patients were treated with intramedullary fixation, while 15 patients were treated with open reduction and plate fixation. Each patient had a successful bone fusion. The intramedullary fixation resulted in an average bone union time of 2.3 months, whereas the plate fixation resulted in an average bone union time of 2.0 months. No significant difference existed between the two groups (78).

After a mean of 4.7 weeks, each patient treated with antegrade intramedullary K-wires for metacarpal fracture fixation reported bone union (4 to 7 weeks). Which corresponded with our findings.

Numerous studies indicate the efficacy of percutaneous k-wiring in the treatment of metacarpal fractures. A study indicated that percutaneous pinning had good functional outcomes, with no functional impairment in patients treated with k-wires (79). In another study, Lee et al. (2013) discovered that k-wires provide early hand movement, cure the deformity, and provide outstanding clinical and radiological outcomes (80).

Furthermore, the functional outcome in terms of postoperative pain and grip strength is much superior to those of open procedures including screws and plates (70).

Our findings revealed that none of the examined populations encountered problems. Contrary to Potenza et al. (2013), who utilized a transverse wiring method in the treatment of 35 metacarpal fractures, removal of Bouquet wires needs re-operation in 50% of instances. Transverse cables do not require reinstallation. At 8 weeks postoperatively, the vast majority of patients had achieved union. Five patients had a little local infection at the Kwire insertion site, which was successfully treated with medication. Two individuals were found to have a moderate limitation in the extension of the fifth MP joint, with a value less than 108, although reporting no significant impairment in hand function. Three patients showed chronic palmar angulation of the fifth metacarpal, averaging 78 degrees (range: 5–138 degrees) with a standard deviation of 5 degrees (81).

Also, Adawy et al., 2022 discovered that the complication rate was low in their 20 patients compared to other studies, with only one patient experiencing stiffness, which gradually improved with physiotherapy, and another patient uniting with a 10o angulation of the 5th metacarpal without functional impairment or extension lag (66). In prior Bouquet pinning clinical studies, 2/41 patients experienced pin tract infection, 2/41 patients

experienced pin migration, and 4/41 patients experienced a little rotational deformity (81). Two patients had a little extensor lag of about 15 degrees, and three patients had a superficial wound infection with surrounding cellulitis; one fracture was repaired owing to poor fixation (82).

Lee et al. observed that during follow-up, 4/56 patients suffered extensor tendon irritation, 3/56 patients got a superficial pin site infection, and 5/56 patients had some stiffness following repair of metacarpal fractures with multiple retrograde K-wires. These studies employed various methodologies (80). In a research employing antegrade intramedullary K-wire for metacarpal fracture repair, 8/150 patients exhibited rotational deformity, while 12/150 patients experienced pin tract infection (71). In addition, 5/35 patients reported a little local infection at the site of K-wire insertion, 2/35 patients reported a modest restriction in the extension of the fifth MP joint, and 3/35 patients reported persistent palmar angulation of the head of the fifth metacarpal (81).

A trial performed by Adawy et al. demonstrated that the radiological and functional outcomes of the transverse K-wires technique were statistically equal to those of other techniques. We believe this because it is very simple and quick (average of 28 minutes) to do, requires less soft tissue dissection, is more biological, and prevents interruption of the periosteal blood supply, allowing for expected bone union in metacarpal shaft fracture. In metacarpal neck fractures, positioning of the wire away from the MP joint had great results (66).

Regarding the difference between both techniques in our study:

Our study showed a significantly shorter duration of surgery belonged to TW. While Bouquet technique showed significantly longer duration of wire removal.

Removal of wires require re-operation in 50% of Bouquet technique, but not Transverse wires, significant association of Transverse wires technique with rapid union when compared to Bouquet technique.

No significant differences between both groups regarding pain intensity. Removal of wires require re-operation in 50% of Bouquet technique, but not Transverse wires.

In addition to the limited sample size and lack of clear criteria for selecting the kind of surgical approach, there was also a short time of follow-up, as this was a retrospective study.

Unlike the bouquet approach, k-wires are adjustable, readily accessible, inexpensive, and surgeon-friendly. They give an adequate range of motion, sufficient grip strength, and an

overall functionally advantageous outcome. In order to provide a practical guideline for selecting an acceptable surgical approach for the stabilization of metacarpal fractures and evaluating functional results, we recommend further prospective clinical studies.

5. Conclusions

Transverse wires are superior than other approaches because they are versatile, easily available, affordable, and surgeon-friendly. They provide an adequate range of motion, sufficient grip strength, and an overall good performance. To give a strong guideline for selecting an acceptable surgical method for the fixation of metacarpal fractures and to evaluate

functional outcomes, we propose further prospective clinical research.

6. Limitation

The current research has certain limitations, such as the small number of patients delivered, the restriction to neonates born in our hospital.

7. Recommendations:

- Large sample size should be conducted to confirm our results.
- Selecting patients and operation should be under screening of specific criteria.
- Longer period of follow-up should be conducted to collect all possible complications.

Table (1) General characteristics

		Cases n=20	
Age	mean±SD	31.6	11.6
	Range	15	52
Gender	males N, %	17	85.0%
	females N, %	3	15.0%

Table (2) Comparison of Duration of surgery and wire removal between studied groups

		Bouquet technique N=10		Transverse wires N=10		<i>p</i>
Duration of surgery (minutes)	mean±SD	27.5	6.8	21.4	5.3	0.038
	Range	20	40	16	32	
wire removal at (weeks)	mean±SD	8.5	0.5	6.2	0.6	<0.001
	Range	8	9	6	8	

Table (3) Comparison of Pain intensity between studied groups.

			Bouquet technique N=10		Transverse wires N=10		<i>p</i>
Pain intensity	No pain	N, %	5	50%	4	40%	0.855
	mild	N, %	3	30%	3	30%	
	moderate	N, %	2	20%	3	30%	
	Pain score	mean±SD	0.7	0.8	0.9	0.9	0.605
	Range	0	2	0	2		

Table (1) Comparison of Dominant Grip strength between studied groups

		Bouquet technique N=10		Transverse wires N=10		<i>p</i>
grip strength %	mean±SD	96.9	3.5	97.1	4.2	0.899
	Range	92	100	90	100	

P, probability

Table (2) Comparison of non Dominant Grip strength between studied groups

		Bouquet technique N=10		Transverse wires N=10		<i>p</i>
grip strength	mean±SD	97.5	3.5	96	5.6	0.781

%	Range	95	100	92	100
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P, probability

Table (6) Comparison of TAM between studied groups

TAM	mean±SD Range	Bouquet technique N=10		Transverse wires N=10		p
		260.1	8.1	259.5	6.9	
		250	270	250	275	

Table (7) Comparison of union between studied groups

Union	6 Weeks 7 Weeks 8 Week	N, % N, % N, %	Bouquet technique N=10		Transverse wires N=10		p
			1	10%	4	40%	
			4	40%	4	40%	
			5	50%	2	20%	
	mean±SD		7.4	0.7	6.8	0.8	0.041
	Range		6	8	6	8	

Table (8) Complications among all studied cases

Complications	N, %	Bouquet technique N=10		Transverse wires N=10		p
		0	0%	0	0%	
Removal of wires require re-operation	N, %	5	50%	0	0%	<0.001

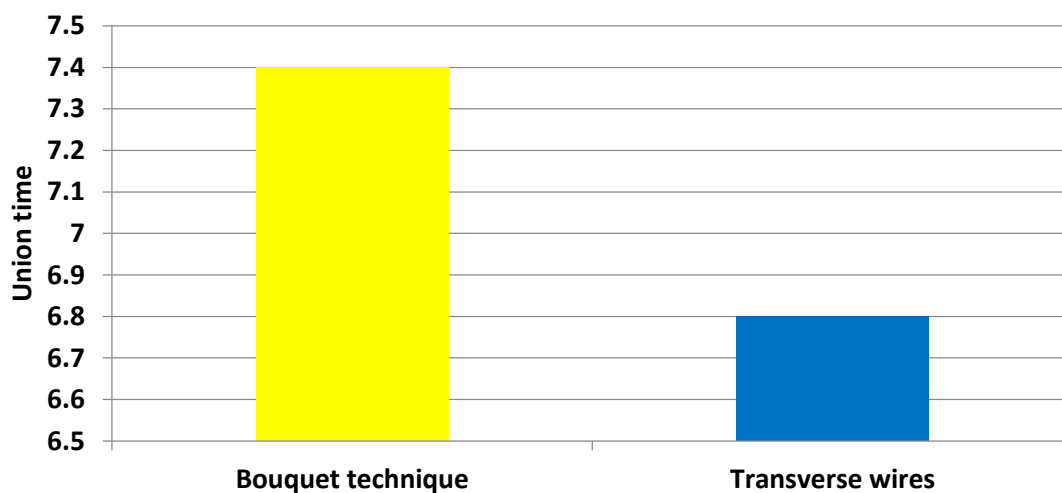


Fig.(1) Union time among studied groups

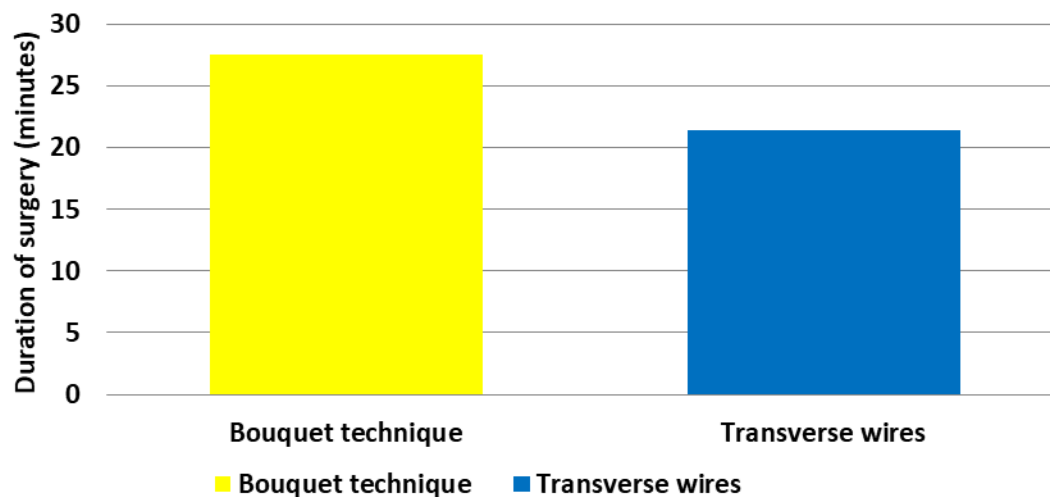


Fig.(2) Duration of surgery among studied groups

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