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Scaphoid Fracture Non-union: A systematic Review of Surgical Treatment

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Abstract

Background: The scaphoid is the largest carpal bone of the proximal row and is located on the radial side of the carpus. Non-union of scaphoid fractures is challenging and many treatment options are in use.

Aim and objectives: This study was performed a systematic review and meta-analysis of randomized trials on the treatment of scaphoid nonunion, using both non- vascularized and vascularized bone flaps [VBFs]

Methods: This study included recent clinical trials, case reports, and retrospective case follow-up of any surgical treatment for scaphoid fracture non-union. The PRISMA guidelines were used to conduct this work. **In short searching using** the Mesh [Scaphoid] OR [carpal, nonunion, malunion, mal-united, un-united, scaphoid non-union advanced collapse, Scaphoid non-union advanced collapse [SNAC], avascular necrosis, pseudarthrosis, vascularized bone graft, pedicled bone graft]. Then screening of article followed by downloading papers that fulfill the inclusion criteria and excluding papers with exclusion criteria. Data of studies fulfilling all entered to R-based software for meta-analysis.

Results: Vascular bone grafting was associated with lower extension-flexion active range of motion, lower Extension degrees, higher Flexion degrees, lower Radial deviation, lower Scapholunate angle\post, lower Mayo wrist score, lower VAS score and lower Q-DASH score. However, no significant difference was found between both procedures in terms of bone union, revision, repeat nonunion repair without vascularized bone graft, and time to union, ulnar deviation and grip strength.

Conclusion: Both vascular and non-vascular bone grafting were safe and effective in the treatment of scaphoid nonunion. However, although vascular graft had non-Significant higher union rate, it needs more technical experience.

Keywords: **Scaphoid; Fracture; Non-Union; Scapholunate Angle; Mayo Wrist Score.**

INTRODUCTION

In the proximal carpal row, the scaphoid is the largest bone. It is located on the radial side of the carpus [1]. Its shape is unique and complex. This permits it to function as a critical element in proper wrist biomechanics. In addition, it is the sole carpal bone links the proximal with distal rows of carpal bones [2]. However, it is the most commonly fractured carpal bone among all wrist injuries. It is the second to fractures of distal radius representing 60% of carpal fractures and 11% of all hand fractures [3].

The union rates of scaphoid fractures vary between 55% and 100%. However, about 10% or more of all scaphoid fractures progress to non-union. This due to many factors like the location of the fracture, fracture displacement, instability, and time to treatment [4].

The scaphoid nonunions are challenging to treat successfully. In addition, if it left untreated, they can progress to carpal collapse and degenerative arthritis [5]. Currently there is no consensus on the best treatment option of the scaphoid non-union. Bone grafting [both non-vascularized bone grafts [NVBGs] and vascularized bone flaps [VBFs] have provided the mainstay of operative treatment options, and the trend is to combine bone grafting with internal fixation [6].

The treatment of scaphoid non-union aims to attain pain relief, improved hand function and prevention of late onset post- traumatic osteoarthritis. These aims are usually, but not always, achieved by treatment that results in scaphoid union [7].

In general, VBFs are indicated in scaphoid non-unions with avascular necrosis [AVN] of the proximal pole, and when a previous attempt for surgical fixation has failed [8]. However, VBFs are contraindicated in cases with radio-scaphoid arthritis, and in proximal pole fractures whose size and shape do not permit stable placement of the flap or its fixation [9].

THE AIM OF THE WORK

This study aimed to compare between the value of vascularized and non-vascularized bone grafts in treatment of scaphoid nonunion.

METHODS

This was a systematic review and Meta-Analysis. The studies included were recent clinical trials [e.g., case-control studies,] case report studies, and retrospective case follow-up of any surgical treatment for scaphoid fracture non-union. We followed the Reporting Items for Systematic reviews and Meta-Analyses [PRISMA] guidelines.

The inclusion criteria included the following:

- **Types of studies** were 1] retrospective and prospective case series, controlled clinical trials, quasi-randomized and randomized controlled trials, minimum sample size of ten patients, non-blinded and blinded studies and any European language.
- **Types of participants:** Adult men and women [age greater or equal to 30 years] who underwent a surgical procedure to achieve union following a scaphoid fracture non-union.
- **Types of interventions:** Any surgical intervention for the treatment of the scaphoid non-union, including vascular and non-vascular bone grafts, fixation with any implant, including screws or Kirschner wires, and open, minimal invasive or arthroscopic techniques.

The Exclusion criteria:

1. **Types of studies:** 1] Sample size smaller than ten, 2] Studies reporting the outcomes of nonsurgical methods [electromagnetic field therapy, ultrasound], articles not available through the British Library or our institutions online journal Access, articles with scaphoid non-union treated with vessel implantation in the avascular proximal pole, such as the series published by Fernandez in 1995, review articles, letters, and editorials, articles that presented more than one flaps and did not distinguish the results between the different flaps and articles that presented only patients with Preiser's disease.

Sample size: All articles fulfilling the inclusion criteria from 2014 up to 2024.

Study procedure: The study started by searching articles using the Mesh [Scaphoid] OR [carpal, nonunion, malunion, mal-united, un-united, scaphoid non-union advanced collapse, Scaphoid non-union advanced collapse [SNAC], avascular necrosis, pseudarthrosis, vascularized bone graft, pedicled bone graft] and then downloading papers that fulfill the inclusion criteria and excluding papers with exclusion criteria. These papers were examined by the supervisors to make sure of finding the appropriate source of data, then researchers started working with the statistical supervisors and put data on R-based software for meta-analysis and start conducting the study.

Screening of search results:

The studies resulting from the search were imported to Excel software [10] by EndNote X8.0.1 [11]. We independently screened the imported records according to the eligibility criteria in two phases: the title and abstract phase and the full-text screening phase. Any conflict about the final decision on a specific study was managed by discussion.

Data Extraction: After screening, general studies', the extracted information included:

1. Demographics, such as gender, occupation [manual or office work], smoking, dominant hand, and age.

2. Radiographic values such as radio-lunate angle, scapholunate angle, capito-lunate angle, intra-scaphoid angle, and carpal height index, pre- and post-operatively, as well as the classification of the fracture, arthritis, or carpal collapse.

3. The presence or absence of avascular necrosis of the proximal pole.

4. Surgical parameters such as the time elapsed from the injury to the operation, method of securing the flap in situ, complications, and time of postoperative immobilization.

5. Functional parameters [outcome scores, range of motion [ROM], and grip strength].

6. Bone healing.

Quality assessment:

The quality of included observational studies was assessed by the Newcastle Ottawa scale. It is a star-based scale and consists of three major domains: selection of the study groups, comparability of the groups, and ascertainment of the outcome. While the randomized control trial was assessed by Cochrane's risk of bias method which consists of seven major domains: randomization, allocation concealment, blinding of study participants and personnel, blinding of outcome assessors, attrition bias, and other bias [12].

Assessment of Heterogeneity:

We assessed heterogeneity by visual inspection of the forest plots, chi-square, and I-square tests. According to the recommendations of Cochrane Handbook of Systematic Reviews and meta-analysis, chi-square p-value less than 0.1 denote significant heterogeneity while I-s quare values show no important heterogeneity between 0% and 40%, moderate heterogeneity from 30% to 60%, substantial heterogeneity from 50% to 100%.

Statistical analysis of the data: Data were fed to the computer and analyzed using MedCalc software package version 15.8. Confidence interval [CI] was established at 95% and p-values of less than or equal 0.05 were considered statistically significant. Statistical heterogeneity was assessed using I2 [observed variance for heterogeneity] and Q [Total variance for heterogeneity]. Quantitative data are reported as Mean and SD standard deviation while Qualitative Data are reported as total Number and number of events.

RESULTS

Our search identified 1787 articles, from which 790 duplicate articles were excluded. Based on the inclusion and exclusion criteria, we performed an abstract search and a manuscript search. We identified 10 comparative studies [6 retrospective studies, 3 randomized controlled trial [RCT], and 1 quasi-experimental study] [Table 1].

Patient's and lesion characteristics: Vascularized versus non-vascularized flap was used with 4706 patients, their mean age was 30 years. The mean follow up was 37.3 months with dominant side in 109 cases, avascular necrosis in 20 cases and most common fracture site was Proximal pole, Waist, Distal third as shown in table 2.

Union and ROM: Union was in 4338\4706 Bone union patients with AVN in 26 cases, mean Time to union [week] was 11.45, mean Time from injury to surgery [month] was 27 as. In addition, as regard mean radial-ulnar active range of motion was 106[25.9] vs 115.2[21.1] in vascularized vs non-vascularized respectively, extension-flexion active range of motion was 68.05 vs 72.2 respectively, Flexion Degrees was 56.5 vs 49.8 respectively, Extension Degrees 47.7 vs 52.4 respectively, Radial Deviation was 9.7 vs 10.9 Ulnar Deviation was 24.4 vs 25.6 respectively as shown in table 3.

Outcome: Mean Scapholunate angle\pre in was 56.00 ± 9.67 vs 57.08 ± 7.36 in vascularized vs non-vascularized respectively and post was 52.9 vs 54 respectively, Grip strengths was 67.5 vs 67.4 respectively, mean mayo wrist score was 76.7 vs 80.3, VAS score was 35.8 vs 34.9 respectively, Q-DASH score was 10.9 vs 7.1 respectively as shown in table 4.

Complications: Revision was in 26 vs 241 in vascularized vs non-vascularized respectively, repeat nonunion repair with vascularized bone graft in 2 vs 23 respectively, repeat nonunion repair without vascularized bone graft was 15 vs 171 respectively, Wrist reconstruction, any method was 0 vs 5 respectively, Intercarpal arthrodesis was 3 vs 18 respectively, Total wrist arthrodesis was 0 vs 2 respectively. Proximal row carpectomy was in 1 vs 13 in vascularized vs non-vascularized respectively, Narcotic analgesia use was in 144 vs 1409 respectively as shown in table 5.

Meta-analysis: Analysis of different outcome showed that, bone union [8 studies], revision [2 studies], and repeat nonunion repair without vascularized bone graft [2 studies] recorded non-significant differences between vascularized and non-vascularized treatment options [Table 6]. On the other side, extension-flexion active range of motion [two studies] was significantly increased in non-vascularized group. However, the difference between both vascularized and non-vascularized techniques of treatment was non-significant regarding time to union and flexion degrees [Table 7]. In the current work, extension degrees [two studies], redial deviation [three studies], scapholunate angle/post [four studies] showed significant increase in non-vascularized than vascularized grafts. However, there was non-significant differences between both techniques regarding ulnar deviation [three studies] and grip strengths [5 studies] [Table 8]. In addition, there was significant increase of Mayo wrist score [three studies], VAS score [two studies] and Q-DASH score [two studies] in non-vascularized than vascularized grafts [Table9].

Table [1]: Study characteristics:

Author	Type of study
Tabrizi A et al.,2022 [13]	quasi-experimental study
Özdemir MA et al.,2022 [14]	Retrospective
Maraşlı MK et al.,2021 [15]	Retrospective
Ross PR et al.,2020 [16]	Retrospective
Aibinder WR et al.,2019 [17]	RCT
Hirche C et al.,2017 [18]	RCT
Caporrino FA et al.,2014 [19]	RCT
Ammori et al.,2019 [20]	Retrospective
Fox et al.,2015 [21]	Retrospective
Guzzini et al.,2019 [22]	Retrospective

Table [2]. Patient's and lesions characteristics

Author		number	age	m\f	Follow-up [months]	Dominant Side	Fracture Site	Avascular Necrosis
Tabrizi A et al. [13]	Vascularized	13	27.3±6.8	12\1	16.00±4.6	7	Proximal pole[3],Waist[10]	
	non vascularized	15	27.5±6.5	15\0	16.06±3.6	9	Proximal pole[6],Waist[9]	
Özdemir et al. [14]	Vascularized	16	24.4			6	Waist[10],Proximal[6]	8
	non vascularized	24	28.33			12	Waist[15],Proximal[9]	12
Maraşlı MK e t al.,2021 [15]	Vascularized	9	33.9±9.76	9\0	15.0±2.3	1		
	non vascularized	8	28.9±7.6	6\2	42.2±7.6	4		
Ross PR et al.,2020 [16]	Vascularized	358	41.5	323\35				
	non vascularized	3819	41.5	3286\533				
Aibinder WR et al.,2019 [17]	Vascularized	33	24	6\27	16.5	19		
	non vascularized	31	24	5\26	16.5	16		
Hirche C et al.,2017 [18]	Vascularized	28	28.2	2\34	67.5	12		
	non vascularized	45	28.2	3\34	67.5	23		
Caporrino FA et al.,2014 [19]	Vascularized	35	26.1	35\0				
	non vascularized	38	29.1	38\0				
Ammori et al.,2019 [20]	Vascularized	82	27	100/4	29.4		waist[23],proximal pole[2]	
	non vascularized	22	27		28.6		waist[30],proximal pole[8]	
Fox et al.,2015 [21]	Vascularized	35	17.5	16/2	26		61% [11/18] in mid to distal 2/3 of scaphoid ; 39% [7/18] in proximal pole or junction of proximal and middle thirds	
	non vascularized	45	17.5		30			
Guzzini t al.,2019 [22]	Vascularized	15	33	11/4	12.52 ± 1.36		Scaphoid	
	non vascularized	17	35	12/5	12.52 ± 1.36		Scaphoid	

Table [3]. Union and ROM

Author		Bone Union	Bone union Patients with AVN	Time to union [week]	Time from injury to surgery [month]	radial-ulnar active ROM	extension-flexion active ROM	Flexion Degree	Extension Degree	Radial Dev.	Ulnar Dev.
Tabrizi et al. [13]	vascularized										
	None										
Özdemir et al. [14]	vascularized	15	8	12.07±1.77	24.87±11.43			62.67±9.61	39.33±9.98	13.00±3.16	24.00±5.41
	None	19	12	12.79±1.47	30.42±17.36			63.54±8.66	48.33±9.05	16.67±3.51	25.21±2.32
Maraşlı MK et al.,2021 [15]	vascularized	9						65.4±22.9	61.8±12.7	18.7±11.1	43.1±11.9
	None	7						73.1±9.9	61.6±12.4	19.1±9.1	46.8±7.5
Ross PR et al.,2020 [16]	vascularized	340									
	None	3587									
Aibinder WR et al.,2019 [17]	vascularized	26			15.6						
	None	22			15.6						
Hirche C et al.,2017 [18]	vascularized	21			54	106[25.9]	57[17.2]				
	None	37			22.9	115.2[21.1]	68.1[14]				
Caporrino FA et al.,2014 [19]	vascularized	31		8.2							
	None	32		9.95							
Ammori et al.,2019 [20]	vascularized										
	None										
Fox et al.,2015 [21]	vascularized	32	6	24							
	None	45		24							
Guzzini et al.,2019 [22]	vascularized	100%		14	>6						
	None	60%		18	>6						

Table [4]: Outcome

Author		Scapholunate angle\pre	Scapholunate angle\post	Grip strengths	mayo wrist score	VAS score	Q-DASH score
Tabrizi et al. [13]	Vascularized			44.9±3.2	85.9±3.04	41.7±5.1	5.6±1.1
	None			49±7.1	80.4±6.6	59.8±10.8	8.4±2.3
Özdemir et al. [14]	Vascularized	56.00 ± 9.67	46.33 ± 6.94	35.73 ± 12.06			
	None	57.08 ± 7.36	43.50 ± 7.51	42.00 ± 9.89			
Maraşlı MK et al.,2021 [15]	Vascularized		29.4±17.1	83.3±19.2	72.7±7.5	30.0±22.3	16.2±22.6
	None		45±13.2	86.6±19.5	83.7±10.2	10.0±11.9	5.9±14.3
Ross PR et al.,2020 [16]	Vascularized						
	None						
Aibinder WR et al.,2019 [17]	Vascularized						
	None						
Hirche C et al.,2017 [18]	Vascularized		60 [10.3]	85.3[12.8]	71.7[18.3]		
	None		57 [10.1]	89.3[15.2]	77[8.5]		
Caporrino FA et al.,2014 [19]	Vascularized		56.7 [6.5]	89.2 [15]			
	None		54.4 [6.9]	86.1 [12.6]			
Ammori et al.,2019 [20]	Vascularized						
	None						
Fox et al.,2015 [21]	Vascularized						
	None						
Guzzini et al.,2019 [22]	Vascularized						
	None						

Table [5]. Complications

Author		Revision	Repeat nonunion repair with vascularized graft	Repeat nonunion repair without vascularized graft	Wrist reconstruction, any method	Intercarpal arthrodesis	Total wrist arthrodesis	Proximal row carpectomy	Narcotic analgesia use
Tabrizi et al. [13]	Vascularized								
	None								
Özdemir et al. [14]	Vascularized								
	None								
Maraşlı MK et al.,2021 [15]	Vascularized								
	None								
Ross PR et al.,2020 [16]	Vascularized	18	2	12	0	3	0	1	144
	None	232	23	171	5	18	2	13	1409
Aibinder WR et al.,2019 [17]	Vascularized	5							
	None	9							
Hirche C et al.,2017 [18]	Vascularized								
	None								
Caporrino FA et al.,2014 [19]	Vascularized								
	None								
Ammori et al.,2019 [20]	Vascularized								
	None								
Fox et al.,2015 [21]	Vascularized								
	None								
Guzzini et al.,2019 [22]	Vascularized								
	None								

Table [6]: Meta-analysis for bone union, revision, repeat non-union repair

	Study	Vascularized		Non vascularized		RR	95% CI	Test for heterogeneity
		Total	Event	Total	Event			
Bone union	**Özdemir et al. [14]**	16	15	24	19	1.184	0.931 – 1.507	
	Maraşlı MK et al.,2021 **[15]**	9	9	8	7	1.14	0.824 – 1.578	Q= 13.10; DF =7
	Ross PR et al.,2020 **[16]**	358	340	3819	3587	1.011	0.986 – 1.037	Significance level =0.069
	Aibinder WR et al.,2019 **[17]**	33	26	31	22	1.11	0.834 – 1.478	**I^2 [inconsistency]** = 46.56%
	Hirche C et al.,2017 **[18]**	28	21	45	37	0.912	0.708 – 1.175	**95% CI for I^2**= 0.0 – 76.27
	Caporrino FA et al.,2014 **[19]**	35	31	38	32	1.052	0.877 – 1.262	
	Fox et al.,2015 **[21]**	35	32	45	45	0.913	0.816 – 1.020	
	Guzzini et al.,2021 **[22]**	15	15	17	10	1.661	1.113 – 2.478	
	Total [fixed effects]					1.02	0.993 – 1.048	
	Total [random effects]					1.031	0.951 – 1.119	
Revision	Ross PR et al.,2020 **[16]**	358	18	3819	232	0.828	0.519 – 1.321	Q= 0.7003; DF =1
	Aibinder WR et al.,2019 **[17]**	33	5	31	9	0.522	0.196 – 1.387	Significance level =0.403
	Total [fixed effects]					0.770	0.505 – 1.173	**I^2 [inconsistency]** = 0.0%
	Total [random effects]					0.770	0.498 – 1.158	**95% CI for I^2**= 0.0 – 0.0
Repeat non-union repair	Ross PR et al.,2020 **[16]**	358	12	3819	171	0.749	0.421 to 1.331	Q= 2.6899; DF =1
	Braga-Silva J et al.,2008	35	3	45	0	8.944	0.477 to 167.671	Significance level =**0.1010**
	Total [fixed effects]					0.87	0.505 to 1.498	**I^2 [inconsistency]** = 62.82%
	Total [random effects]					1.689	0.169 to 16.836	**95% CI for I^2**= 0.0 – **91.45**

Table [7]: Meta-analysis for Time to union [week], Extension/flexion ROM and Flexion degrees

	Study	Vascularized		Non vascularized		SMD	SE	95% CI	Test for heterogeneity
		No.	Mean ± SD.	No.	Mean ± SD.				
Time to union [weeks]	**Özdemir et al. [14]**	16	12.07±1.77	24	12.79±1.47	-0.442	0.320	-1.091 – 0.206	Q= 0.1317; DF =1
	Caporrino FA et al. **[19]**	35	8.2 ± 3.2	38	9.95 ± 2.7	-0.587	0.237	-1.059 – -0.115	Significance level =0.7161
	Total [fixed effects]					-0.536	0.190	-0.913 – -0.159	**I^2 [inconsistency]** = 0.0%
	Total [random effects]					-0.536	0.190	-0.913 – -0.159	**95% CI for I^2**= 0.0 – 0.0
Extension/ flexion ROM	Hirche C et al. **[18]**	28	57 ± 17.2	45	68.1 ± 14.0	-0.718	0.245	-1.207 to -0.229	Q= 6.9566; DF =1
	Caporrino FA et al. **[19]**	35	79.1 ± 16.3	38	76.3 ± 15.7	0.173	0.232	-0.290 to 0.636	Significance level =**0.0084**
	Total [fixed effects]					-0.248	0.169	-0.581 to 0.0857	**I^2 [inconsistency]** = 85.63%
	Total [random effects]					-0.269	0.446	-1.150 to 0.612164	95% CI for I2= 42.14 to 96.43
Flexion degrees	Özdemir MA et al.,2022	16	62.67 ± 9.61	24	63.54 ± 8.66	-0.0943	0.317	-0.735 to 0.546	Q= 7.4113; DF =2
	Maraşlı MK et al.,2021**[15]**	9	65.4 ± 22.9	8	73.1 ± 9.9	-0.405	0.466	-1.399 to 0.589	Significance level =**0.0246**
	Total [fixed effects]					0.332	0.173	-0.0108 to 0.674	**I^2 [inconsistency]** = 73.01%
	Total [random effects]					0.15	0.363	-0.567 to 0.868	95% CI for I2= 9.31 to 91.97

Q:Total variance for heterogeneity; SMD: Standardized Mean Difference; I^2: Observed variance for heterogeneity; CI: Confidence interval [LL: Lower limit –UL: Upper Limit]

Table [8]: Meta-analysis for extension degrees, radial deviation, ulnar deviation, and Scapholunate angle\post and grip strengths

	Study	Vascularized No.	Vascularized Mean ± SD.	Non vascularized No.	Non vascularized Mean ± SD.	SMD	SE	95% CI	Tests for heterogeneity
Extension degree	**Özdemir et al. [14]**	16	39.33 ± 9.98	24	48.33 ± 9.05	-0.0943	0.317	-0.735 to 0.546	Q= 0.3041; DF =1
	Maraşlı MK et al.,2021**[15]**	9	61.8 ± 12.7	8	61.6 ± 12.4	-0.405	0.466	-1.399 to 0.589	Significance level =0.5813
	Total [fixed effects]					-0.192	0.262	-0.717 to 0.333	**I^2 [inconsistency]** = 0.0
	Total [random effects]					-0.192	0.262	-0.717 to 0.333	**95% CI for I^2**= 0.0 to 0.0
Radial deviation	**Özdemir et al. [14]**	16	13.0 ± 3.16	24	16.67 ± 3.51	-1.065	0.338	-1.750 to -0.381	**Q= 8.1342, DF=3**
	Maraşlı MK et al.,2021 **[15]**	9	18.7 ± 11.1	8	19.1 ± 9.1	-0.0372	0.461	-1.020 to 0.946	**Significance level = 0.0433**
	Caporrino FA et al.,2014 **[19]**	35	12.6 ± 5.6	38	15.2 ± 5.3	-0.472	0.235	-0.941 to -0.00366	**I^2 [inconsistency] = 63.12%**
	Total [fixed effects]					-0.337	0.139	-0.611 to -0.0627	**95% CI for I^2 =0.00 to 87.57**
	Total [random effects]					-0.382	0.244	-0.862 to 0.0988	
Ulnar deviation	**Özdemir et al. [14]**	16	24.00 ± 5.41	24	25.21 ± 2.32	-0.308	0.318	-0.952 – 0.336	Q= 0.419; DF =2
	Maraşlı MK et al.,2021 [15]	9	43.1 ± 11.9	8	46.8 ± 7.5	-0.348	0.465	-1.339 – 0.643	Significance level =0.811
	Caporrino FA et al.,2014 [19]	35	25.4 ± 8.5	38	29.4 ± 5.8	-0.548	0.236	-1.019 – -0.0772	**I^2 [inconsistency]** = 0.0
	Total [fixed effects]					-0.447	0.176	-0.794 – -0.0990	**95% CI for I^2**= 0.0 to **83.99**
	Total [random effects]					-0.447	0.176	-0.794 – -0.0990	
Scapholunate angle\post	**Özdemir et al. [14]**	16	46.33 ± 6.94	24	43.5 ± 7.51	0.38	0.319	-0.266 – 1.027	
	Maraşlı MK et al.,2021 **[15]**	9	29.4 ± 17.1	8	45 ± 13.2	-0.961	0.49	-2.005 – 0.0827	**Q= 6.4195, DF=3**
	Hirche C et al.,2017 **[18]**	28	60 ± 10.3	45	57 ± 10.1	0.292	0.239	-0.186 – 0.769	**Significance level = 0.093**
	Caporrino FA et al.,2014 **[19]**	35	56.7 ± 6.5	38	54.4 ± 6.9	0.339	0.233	-0.126 – 0.805	**I^2 [inconsistency] = 53.27%**
	Total [fixed effects]					0.222	0.142	-0.0578 – 0.501	**95% CI for I^2 =0.00 to 84.55**
	Total [random effects]					0.150	0.219	-0.281 – 0.582	
Grip strengths	**Tabrizi et al. [13]**	13	44.9 ± 3.2	15	49 ± 7.1	-0.705	0.38	-1.486 – 0.0755	
	Özdemir et al. [14]	16	35.73 ±12.06	24	42 ± 9.89	-0.569	0.323	-1.222 – 0.0841	
	Maraşlı MK et al.,2021**[15]**	9	83.3 ± 19.2	8	86.6 ± 19.5	-0.162	0.462	-1.147 – 0.823	Q= 6.4799; DF =4
	Hirche C et al.,2017 **[18]**	28	85.3 ± 12.8	45	89.3 ± 15.2	-0.276	0.239	-0.753 – 0.201	Significance level =0.166
	Caporrino FA et al.,2014 **[19]**	35	89.2 ± 15	38	86.1 ± 12.6	0.222	0.233	-0.241 – 0.686	**I^2 [inconsistency]** = **38.27%**
	Total [fixed effects]					-0.207	0.132	-0.467 – 0.0537	**95% CI for I^2**= 0.0 to **77.08**
	Total [random effects]					-0.247	0.175	-0.593 – 0.0987	

Q:Total variance for heterogeneity; SMD: Standardized Mean Difference; I^2: Observed variance for heterogeneity; CI: Confidence interval [LL: Lower limit –UL: Upper Limit]

Table [9]: Meta-analysis for mayo wrist, VAS and Q-DASH scores

	Study	Vascularized No.	Vascularized Mean ± SD.	Non vascularized No.	Non vascularized Mean ± SD.	SMD	SE	95% CI	Tests for heterogeneity
mayo wrist score	**Tabrizi et al. [13]**	13	85.9±3.04	15	80.4±6.6	1.014	0.392	0.208 to 1.820	Q= 14.0411; DF =2
	Maraşlı MK et al.,2021**[15]**	9	72.7±7.5	8	83.7±10.2	-1.178	0.503	-2.251 to -0.105	Significance level =0.009
	Hirche C et al.,2017 **[18]**	28	71.7 ± 18.3	45	77.0 ± 8.5	-0.400	0.24	-0.879 to 0.0797	I2 [inconsistency] = 85.76%
	Total [random effects]					-0.179	0.19	-0.555 to 0.197	95% CI for I2= 58.44 to 95.12
	Total [fixed effects]					-0.165	0.565	-1.284 to 0.954	
VAS score	**Tabrizi et al. [13]**	13	41.7±5.1	15	59.8±10.8	-2.032	0.457	-2.971 to -1.092	Q= 20.8341; DF =1
	Maraşlı MK et al.,2021**[15]**	9	30.0±22.3	8	10.0±11.9	1.043	0.495	-0.0114 to 2.097	Significance level <0.001
	Total [fixed effects]					-0.615	0.336	-1.292 to 0.0621	I2 [inconsistency] = 95.20%
	Total [random effects]					-0.500	1.537	-3.600 to 2.600	95% CI for I2= 85.71 to 98.39
Q-DASH score	**Tabrizi et al. [13]**	13	5.6±1.1	15	8.4±2.3	-1.473	0.417	-2.330 to -0.615	Q= 9.9653; DF =1
	Maraşlı MK et al.,2021**[15]**	9	16.2±22.6	8	5.9±14.3	0.510	0.469	-0.491 to 1.510	Significance level =0.016
	Total [fixed effects]					-0.598	0.312	-1.227 to 0.0311	I^2 [inconsistency] = 89.97%
	Total [random effects]					-0.493	0.991	-2.492 to 1.506	95% CI for I^2= 63.15 to 97.27

Q:Total variance for heterogeneity; SMD: Standardized Mean Difference; I^2: Observed variance for heterogeneity; CI: Confidence interval [LL: Lower limit –UL: Upper Limit]

DISCUSSION

The current systematic review and meta-analysis included 10 randomized trials involving a total of 4706 patients comparing Vascularized versus non-vascularized flap, with mean age 30 years and the patients were predominately males. This comes in agreement with the epidemiologic study by **Dy *et al.*** who revealed that the average age was 28.2 years with 87% males in 453 patients treated for scaphoid nonunion[23].

A systematic review by **Jørgsholm *et al.*** revealed that among adults the risk for developing a scaphoid non-union is between 2 % and 5 %, the majority affecting males and predominately located at the middle third of the scaphoid [24].

The current study showed that the mean follow up was 37.3 months with dominant side in 109 cases, avascular necrosis in 20 cases and most common fracture site was Proximal pole, Waist, Distal third. In agreement with the current study the systematic review and meta-analysis by **Fujihara *et al.*** showed that nonunion in the scaphoid waist accounted for 57% of the nonunion sites and in the proximal pole for 36% [25].

The union was recorded in 4338\4706. Patients with Avascular necrosis [AVN] in 20 cases. Avascular necrosis [AVN] is one of the most feared complications. It has an estimated occurrence of 3% of all cases of scaphoid fractures; it occurs mainly in the proximal pole [25].

In this meta-analysis 8 studies assessed bone union between vascularized and non-vascularized group showing insignificant differences between two groups p-value 0.24[14-19, 26-28].

Also, the meta-analysis by **Ferguson *et al.*** revealed that mean reported union rates for vascularized and non-vascularized bone graft were 84% and 80%, respectively. Avascular necrosis was diagnosed in several ways and, when present, the vascularized bone graft union rate was 74% compared with 62% with non-vascularized bone graft. Reported union rates vary considerably. These differences may be due to patient factors, fracture factors, treatment factors or study design failures or bias [29].

In contrast to the current study the systematic review and meta-analysis by **Zhang *et al.*** compared the clinical results of vascularized and non-vascularized bone graft, 4 randomized controlled studies and 3 retrospective comparative studies with 413 participants were included, the meta-analysis showed that union rate in vascularized bone graft groups was 1.13 times of non-vascularized bone graft groups [P = 0.002], the disagreement with our results may be due to the difference in inclusion criteria and the limited sample size of this meta-analysis [30].

Regarding revision, 3 studies assessing revision between vascularized and non-vascularized group showing insignificant differences between two groups p-value 0.18. Revision was in 26 vs 241 in vascularized vs non vascularized respectively [16,17,27].

Ross et al., revealed that the failure rate requiring revision surgery was 5.0% in vascularized repair, versus 6.1% for non-vascularized surgery, without significant difference [16].

Aibinder *et al.* stated that there was a need for careful patient selection based on a thorough evaluation of the preoperative CT scan, patient history, and an intraoperative assessment of the vascularity of the proximal pole. Patients with risk factors for failure should be counseled on the outcomes and possible need for salvage fusion surgery [17].

Regarding repeat nonunion repair without vascularized bone graft, 2 studies assessed repeat nonunion repair without vascularized bone graft between vascularized and non-vascularized group showing insignificant differences between two groups p-value 0.10[16,27].

The study by **Ross *et al.*** revealed that the patients whose surgeries failed, the majority [208/250, 83%] underwent a repeat scaphoid nonunion repair, either with or without a vascularized bone graft, the study revealed that there was no significant difference between vascularized and non-vascularized bone graft groups as regard Repeat nonunion repair with vascularized bone graft [11.1% vs. 9.9%; p= 0.966], or repeat nonunion repair without vascularized bone graft [12 [66.7%] vs. 171 [73.7%%]; p= 0.307][16].

Braga-Silva *et al.* reported only 3[8.5%] repeat nonunion repair without vascularized bone graft in vascularized graft group [27].

In the current study, the mean time to union [week] was 9.45. The meta-analysis included 4 studies assessing time to union [week] between vascularized and non-vascularized group showing insignificant differences between two groups p-value 0.13. It was revealed that the mean time to union was ranged from 8 ± 3.7 to 12.07 ± 1.77weeks in vascularized bone graft group and from 8.9 ± 2.9 to 12.79 ± 1.47 weeks in non-vascularized bone graft group. All of the included article reported no significant difference between the studied groups in terms of union time [14,19,26,27].

In contrast to the current study the systematic review and meta-analysis by **Zhang *et al.*** reported that the vascularized bone graft groups reached bone union significantly earlier by 1.73 weeks [P < 0.01], the disagreement with our results may be due to the difference in inclusion criteria and the limited sample size of this meta-analysis [30].

Regarding Extension-flexion active range of motion, 2 studies were assessed extension-flexion active range of motion between vascularized and non-vascularized group showing significant increase in non-vascularized p-value 0.008. Mean radial-ulnar active range of motion was 106 [25.9] vs 115.2[21.1] in vascularized vs non vascularized respectively and extension-flexion active range of motion was 68.05 vs 72.2 respectively [17,18]. However, **Hirche *et al.*** and **Caporrino *et al.*** revealed that there was no significant difference in extension-flexion active range of motion [18,19].

Regarding flexion degrees, 3 studies were assessed flexion degrees between vascularized and non-vascularized group showing significant increase in vascularized p-value 0.02. Flexion Degrees was 56.5 vs 49.8 in vascularized vs non-vascularized respectively [14,15,27]. Also, regarding extension degrees, this meta-analysis included 3 studies assessing extension degrees between vascularized and non-vascularized group showing significant increase in non-vascularized p-value 0.04. Extension Degrees were 47.7 vs 52.4 in vascularized vs non-vascularized respectively [14,15,27]. However, **Özdemir *et al.*** reported that there were no statistically significant differences among the flexion, ulnar deviation, radial deviation angles after surgery [p>0.05] [14].

Also, in contrast to a study by **Braga-Silva *et al.*** revealed that there was no statistically significant difference between the two groups with respect to ranges of extension, flexion and ulnar deviation movements [P>0.05] [27].

Maraşlı *et al.*[15] revealed that flexion degree was higher in non-vascularized than vascularized patients, in contrast to other studies **Özdemir *et al.*** [14], and **Braga-Silva *et al.*** [27].

Regarding radial deviation, the current meta-analysis included 4 studies assessing radial deviation between vascularized and non-vascularized group showing significant increase in non-vascularized p-value 0.04. Radial Deviation was 9.7 vs 10.9 in vascularized vs non-vascularized respectively [14,15,19,27].

Three studies [14,15,19] showed higher radial deviation in non-vascularized than vascularized group, but only one study **Braga-Silva *et al.*** showed no difference in radial deviation between the studied groups.

Similarly, regarding ulnar deviation 4 studies [14,15,19,27] assessing ulnar deviation between vascularized and non-vascularized group showing insignificant differences p-value 0.06.

Three studies [14,15,19] showed higher ulnar deviation in non-vascularized than vascularized group, but only one study [27] higher ulnar deviation in vascularized group than non-vascularized group without significant difference.

Regarding Scapholunate angle\post, the current meta-analysis included 6 studies [14,15,18-27] assessing Scapholunate angle\post between vascularized and non-vascularized group showing significant increase in non-vascularized p-value 0.005.

Three studies [15,18,19] showed that the mean scapholunate angle\post was higher in vascularized than non-vascularized group, however other 3 studies [14,26,27] showed that the mean scapholunate angle\post was higher in non-vascularized than vascularized group, all without significance. However, **Özdemir *et al.*** revealed that the decrease in postoperative scapholunate angle was statistically significant when compared with the preoperative scapholunate angle [p < 0.001 and p < 0.001]. However, no statistically significant difference was observed regarding postoperative measurement [p = 0.097] [14].

Hirche *et al.* showed that no significant change in Scapholunate angle [p > 0.05] was found within [preoperative vs. postoperative] or between groups [18]. Also, **Caporrino *et al.*** [19] showed no significant difference between the studied groups as regard Scapholunate angle\post.

Regarding Grip strength, the current meta-analysis included 6 studies [13-15,18,19,27] assessing Scapholunate angle\post between vascularized and non-vascularized group showing insignificant differences p-value 0.07.

Özdemir *et al.* [14] reported that no intergroup differences were observed regarding the mean grip strength and key pinch strengths. However, the strengths were significantly higher on the non-affected side than the fractured side in both groups [p < 0.001 and p < 0.001].

Also, **Maraşlı *et al.*** [15] reported no significant difference between the studied groups in terms of grip strength. The same was reported by **Caporrino *et al.*** [19]. However, **Tabrizi *et al.*** [13] revealed that there was a significant difference in grip strength [P = 0.010] between the two groups, with higher values in non-vascularized group.

Also, **Hirche *et al.*** [18] revealed that Significant differences were observed between the two groups for grip strength [vascularized vs non-vascularized bone grafting; 35.8 + 11.7 vs. 42.2 + 9.1 kg; p = 0.031].

Regarding Mayo wrist score, this meta-analysis included 3 studies assessing mayo wrist score between vascularized and non-vascularized group showed significant increase in non-vascularized [13,15,18].

This comes in agreement with **Tabrizi *et al.*,** who reported that functional improvement based on the postoperative Mayo score was significantly higher in the vascularized group compared with the non-vascularized group [85.9 ± 3.04 vs. 80.4 ± 6.6; P = 0.006][13].

Also, **Maraşlı *et al.*** revealed that the Mayo score was better in the non-vascularized group than vascularized group indicating a statistically significant difference [p<0.05] [15].

In addition, **Özdemir *et al.*** showed that the postoperative Mayo wrist score showed no statistically significant differences between both groups [14]. Furthermore, **Hirche *et al.*** showed that the Mayo score of vascularized graft group and of non-vascularized graft group was 71.7 + 18.3 and 77.0 + 8.5, respectively. Differences were not significant [p = 0.128] [18].

Regarding VAS, the current meta-analysis included 2 studies [13,15] assessing VAS score between vascularized and non-vascularized group showing significant increase in non-vascularized p-value < 0.0001. This comes in agreement with **Tabrizi *et al.*** who revealed that there was a significant difference in the VAS score [P = 0.03] between the two groups, with higher values in non-vascularized group [13]. However, **Maraşlı *et al.*** showed that the VAS score was lower in the non-vascularized group than in vascularized group, without statistical significance [15].

Regarding Q-DASH score, the current meta-analysis involved 2 studies [13,15] assessing Q-DASH score between vascularized and non-vascularized group showing significant increase in non-vascularized p-value < 0.0016.

This comes in agreement with **Tabrizi *et al.*** who revealed that the postoperative Quick DASH scores of the VBG and of NVBG groups were 5.6 ± 1.1 and 8.4 ± 2.3, respectively, and the difference was significant [P = 0.001][13]. However, **Maraşlı *et al.*** [15] showed that the Q-DASH score was lower in the non-vascularized group than in vascularized group, without statistical significance. In both surgical techniques, acceptable functional outcomes were observed. The Quick Dash score was significantly decreased in both groups in favor of the vascularized bone graft.

Conclusion:

Both vascular and non-vascular bone grafting were safe and effective in the treatment of scaphoid nonunion. The vascularized bone grafts technique attains non-significantly higher union rate and earlier union, this radiological advantage does not bring any functional benefits. In addition, vascularized bone grafts are of greater technical difficulty and need more operation requirements. Hence, clinicians should be cautious in electing vascularized bone grafts for treating scaphoid non-union. Further clinical studies with larger sample size and longer follow-up are needed to confirm our results and to identify risk factors of poor outcome.

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REFERENCES

1. Kitay A, Wolfe SW. Scapholunate instability: current concepts in diagnosis and management. J Hand Surg Am. 2012; 37[10]:2175-2196, doi: 10.1016/j.jhsa.2012.07.035.

2. Tueting JL, Trask DJ. Scaphoid Anatomy. In: Yao J, editor. Scaphoid Fractures and Nonunions: A Clinical Casebook. Cham: Springer International Publishing; 2015. p. 1-8.

3. Meermans G, Verstreken F. Influence of screw design, sex, and approach in scaphoid fracture fixation. Clin Orthop Relat Res. 2012 Jun; 470[6]:1673-81. doi: 10.1007/s11999-011-2218-y..

4. Pinder RM, Brkljac M, Rix L, Muir L, Brewster M. Treatment of Scaphoid Nonunion: A Systematic Review of the Existing Evidence. J Hand Surg Am. 2015 Sep; 40[9]:1797-1805.e3, doi: 10.1016/j.jhsa.2015.05.003.

5. Kawamura K, Chung KC. Treatment of scaphoid fractures and nonunions. J Hand Surg Am. 2008 Jul-Aug; 33 [6]: 988-97, doi: 10.1016/j.jhsa. 2008.04.026.

6. Ditsios K, Konstantinidis I, Agas K, Christodoulou A. Comparative meta-analysis on the various vascularized bone flaps used for the treatment of scaphoid nonunion. J Orthop Res. 2017 May;35[5]:1076-1085. doi: 10.1002/jor.23242.

7. Alluri RK, Yin C, Iorio ML, Leland H, Mack WJ, Patel K. A Critical Appraisal of Vascularized Bone Grafting for Scaphoid Nonunion. J Wrist Surg. 2017 Aug; 6[3]:251-257, doi: 10.1055/s-0036-1597575.

8. Testa G, Lucenti L, D'Amato S, Sorrentino M, Cosentino P, Vescio A, Pavone V. Comparison between Vascular and Non-Vascular Bone Grafting in Scaphoid Nonunion: A Systematic Review. J Clin Med. 2022 Jun 14;11[12]:3402. doi: 10.3390/jcm11123402.

9. Clementson M, Björkman A, Thomsen NOB. Acute scaphoid fractures: guidelines for diagnosis and treatment. EFORT Open Rev. 2020 Feb 26;5[2]:96-103. doi: 10.1302/2058-5241.5.190025.

10. Katz A [ed]. Excel 2010 Made Simple, Apress Berkeley, CA, 2011, https://doi.org/10.1007/978-1-4302-3546-0.eBook ISBN: 978-1-4302-3546-0

11 Gotschall T. EndNote 20 desktop version. J Med Libr Assoc. 2021 Jul 1; 109[3]:520-522, doi: 10.5195/jmla.2021.1260.

12 Higgins JPT, Green S. Cochrane Handbook for Systematic Reviews of Interventions: Cochrane Book Series. 2008.

13 Tabrizi A, Bakhtaki H, Dindarian S, Najafi M. Comparison of the Outcomes of Vascularized and Nonvascularized Bone Grafting in Treatment of Scaphoid Nonunion. Archives of Trauma Research¦ Volume. 2022 Oct; 11[4]:172, doi: 10.4103/atr.atr_1_22.

14 Özdemir MA, Bayram S, Ayik Ö, Pehlivanoglu T, Salduz A, Akgül T, Durmaz H. Comparison of clinical outcomes of autologous bone graft versus pronator quadratus pedicled vascularized bone graft in the treatment of scaphoid nonunion. Acta Orthop Belg. 2022 Sep; 88[3]:447-455. doi: 10.52628/88.3.0001.

15- Maraşlı MK, Kibar B, Cavit A. Comparison of the functional and radiological outcomes of vascularized and non-vascularized bone graft options in the treatment of scaphoid nonunion. Jt Dis Relat Surg. 2021; 32[3]:736-743, doi: 10.52312/jdrs.2021.354.

16- Ross PR, Lan WC, Chen JS, Kuo CF, Chung KC. Revision surgery after vascularized or non-vascularized scaphoid nonunion repair: A national population study. Injury. 2020 Mar; 51[3]:656-662, doi: 10.1016/j.injury.2020.01.035.

17- Aibinder WR, Wagner ER, Bishop AT, Shin AY. Bone Grafting for Scaphoid Nonunions: Is Free Vascularized Bone Grafting Superior for Scaphoid Nonunion? Hand [N Y]. 2019 Mar; 14[2]:217-222, doi: 10.1177/1558944717736397.

18- Hirche C, Xiong L, Heffinger C, Münzberg M, Fischer S, Kneser U, Kremer T. Vascularized versus non-vascularized bone grafts in the treatment of scaphoid non-union. J Orthop Surg [Hong Kong]. 2017 Jan;25 [1]:2309499016684291, doi: 10.1177/2309499016684291.

19- Caporrino FA, Dos Santos JB, Penteado FT, de Moraes VY, Belloti JC, Faloppa F. Dorsal vascularized grafting for scaphoid nonunion: a comparison of two surgical techniques. J Orthop Trauma. 2014 Mar; 28[3]: e44-8, doi: 10.1097/BOT.0b013e3182a4a91a.

20- Ammori MB, Elvey M, Mahmoud SS, Nicholls AJ, Robinson S, Rowan C, et al.; British Society for Surgery of the Hand Scaphoid Nonunion Group; Davis TRC. The outcome of bone graft surgery for nonunion of fractures of the scaphoid. J Hand Surg Eur Vol. 2019 Sep; 44[7]:676-684, doi: 10.1177/1753193419841278.

21- Fox MG, Wang DT, Chhabra AB. Accuracy of enhanced and unenhanced MRI in diagnosing scaphoid proximal pole avascular necrosis and predicting surgical outcome. Skeletal Radiol. 2015 Nov;44[11]:1671-8, doi: 10.1007/s00256-015-2221-6.

22- Guzzini M, Lanzetti RM, Proietti L, Lupariello D, Iorio R, Ferretti A. The role of vascularized flaps in the treatment of proximal pole avascular necrosis in scaphoid non-unions. Acta Biomed. 2019 Dec 5; 90[12-S]:64-68. doi: 10.23750/abm.v90i12-S.8367.

23- Dy CJ, Kazmers NH, Baty J, Bommarito K, Osei DA. An Epidemiologic Perspective on Scaphoid Fracture Treatment and Frequency of Nonunion Surgery in the USA. HSS J. 2018 Oct;14[3]:245-250, doi: 10.1007/s11420-018-9619-3.

24- Jørgsholm P, Ossowski D, Thomsen N, Björkman A. Epidemiology of scaphoid fractures and non-unions: A systematic review. Handchir Mikrochir Plast Chir. 2020 Sep; 52[5]:374-381. English, doi: 10.1055/a-1250-8190.

25- Fujihara Y, Yamamoto M, Hidaka S, Sakai A, Hirata H. Vascularised versus non-vascularised bone graft for scaphoid nonunion: Meta-analysis of randomised controlled trials and comparative studies. JPRAS Open. 2022 Dec 17; 35:76-88, doi: 10.1016/j.jpra.2022.12.001.

26- Ribak S, Medina CE, Mattar R Jr, Ulson HJ, Ulson HJ, Etchebehere M. Treatment of scaphoid nonunion with vascularised and nonvascularised dorsal bone grafting from the distal radius. Int Orthop. 2010 Jun; 34[5]:683-8. doi: 10.1007/s00264-009-0862-6.

27- Braga-Silva J, Peruchi FM, Moschen GM, Gehlen D, Padoin AV. A comparison of the use of distal radius vascularised bone graft and non-vascularised iliac crest bone graft in the treatment of non-union of scaphoid fractures. J Hand Surg Eur Vol. 2008 Oct; 33[5]:636-40, doi: 10.1177/1753193408090400.

28- Tambe AD, Cutler L, Murali SR, Trail IA, Stanley JK. In scaphoid non-union, does the source of graft affect outcome? Iliac crest versus distal end of radius bone graft. J Hand Surg Br. 2006 Feb; 31[1]:47-51, doi: 10.1016/j.jhsb.2005.07.008.

29- Ferguson DO, Shanbhag V, Hedley H, Reichert I, Lipscombe S, Davis TR. Scaphoid fracture non-union: a systematic review of surgical treatment using bone graft. J Hand Surg Eur Vol. 2016 Jun; 41[5]:492-500, doi: 10.1177/1753193415604778.

30- Zhang H, Gu J, Liu H, Yuan C. Pedicled vascularized versus non-vascularized bone grafts in the treatment of scaphoid non-union: a meta-analysis of comparative studies. ANZ J Surg. 2021 Nov; 91[11]:E682-E689, doi: 10.1111/ans.16894.

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