Lisfranc and Chopart amputation

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Lisfranc and Chopart amputation
A systematic review

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Abstract

Background: Lisfranc and Chopart amputations are historically controversial procedures. To obtain evidence for the pros and cons we performed a systematic review to analyze wound healing, the need for re-amputation at a higher level, and ambulation after a Lisfranc or Chopart amputation.

Methods: A literature search was performed in 4 databases (Cochrane, Embase, Medline, and PsycInfo), using database-specific search strategies. Reference lists were studied to include relevant studies that were missed in the search. Of the 2881 publications found, 16 studies could be included in this review. Excluded publications concerned editorials, reviews, letters to the editor, no full text available, case reports, not meeting the topic, and written in a language other than English, German, or Dutch.

Results: Failed wound healing occurred in 20% after Lisfranc amputation, in 28% after modified Chopart amputation, and 46% after conventional Chopart amputation. After Lisfranc amputation, 85% of patients were able to ambulate without prosthesis for short distances, and after modified Chopart 74%. After a conventional Chopart amputation, 26% (10/38) had unlimited household ambulation.

Conclusions: The need for re-amputation because wound healing problems occurred most frequently after conventional Chopart amputation. All 3 types of amputation levels do, however, provide a functional residual limb, with the remaining ability to ambulate without prosthesis for short distances. Lisfranc and modified Chopart amputations should be considered before proceeding to a more proximal level of amputation. Further studies are needed to identify patient characteristics to predict favorable outcomes of Lisfranc and Chopart amputations.

Abbreviations: DM = diabetes mellitus, FAC = functional ambulation classification, SPG = symmetrical peripheral gangrene.

Keywords: amputation, Chopart, Lisfranc, outcome studies

1. Introduction

Amputation of the foot may be required in case of vascular diseases, diabetes, a life-threatening infection, malignancy, and severe foot trauma. Surgeons may choose partial foot amputation such as trans-metatarsal amputations or when pathologies are too extended, a trans-tibial amputation to treat these conditions. Trans-tibial amputations or lower extremity amputation in general, however, result regularly in postoperative morbidity and mortality, because of decreased ambulatory status.[1–3]

If a more proximal amputation than a trans-metatarsal amputation is indicated, a Lisfranc or Chopart amputation may be considered before proceeding to a more proximal level of amputation like a trans-tibial amputation. Lisfranc amputation is a disarticulation at the tarsometatarsal level. Chopart amputation is a disarticulation at the talonavicular and calcaneocuboid level. Benefits of both amputation types include a higher level of ambulation because of preserving limb length compared to trans-tibial amputation and walking short distances without prosthesis because direct loading of the residual limb is possible.[4,5] Both amputation types are however controversial because of their postoperative problems, which include difficulties in wound healing, equinus contracture, and the need for re-amputation.[4,6–8]

After the introduction of Lisfranc and Chopart amputation, several modifications have been described to improve functional outcomes and wound healing. In order to preserve dorsal flexion after performing a Lisfranc amputation, it is recommended to maintain the base of the first and fifth metatarsals to preserve as much ankle function as possible.[7,9] To prevent an equinus contracture and distal breakdown of the residual limb after a Chopart amputation, an Achilles tenectomy is frequently performed.[7] Other modifications include anchoring the anterior tibialis tendon into the neck of the talus or transferring the posterior tibial tendon to the talus, or utilizing a new technique of balanced tendon transfer modification to the Chopart amputation.[7,10–12]

Despite these modifications, Lisfranc and Chopart amputations are still controversial. In order to find evidence for the

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pros and cons and therewith to predict outcomes of Lisfranc and Chopart amputation, we performed a systematic review to analyze wound healing, need for re-amputation, equinus deformity, and ambulation after these types of amputation.

2. Methods

A literature search was performed in Cochrane, Embase, Medline/Pubmed, and PsycInfo databases until the end of March 2020 with the assistance of an information specialist (librarian). Free text, using keywords and synonyms for Lisfranc and Chopart amputation, including MESH terms, were used in the different searches of the databases. For MEDLINE/Pubmed, the following search strategy was used: partial foot amputation [tiab] OR Lisfranc [tiab] OR Chopart [tiab] OR trans-metatarsal amputation [tiab] OR midfoot amputation [tiab] OR forefoot amputation [tiab]. Adapted search strategies were used in the other databases (Appendix S1, Supplemental Digital Content, http://links.lww.com/MD/I612). Because this is a review, no ethical approval was necessary.

The search was limited to the English, German, and Dutch language, with no restrictions on publication date and patient age. Duplications were removed. Of the remaining publications titles and abstracts were assessed by 2 reviewers (GW and JG) independently.

Studies were included in this review if they reported on wound healing, the need for amputation at a more proximal level, and ambulation level after Lisfranc or Chopart amputation. Excluded from this review were editorials, (expert) reviews, letters to the editor, case reports, publications of which no full text was available after library requests, publications without result differentiation between Lisfranc and Chopart amputations, or not meeting the topic.

Cohen kappa and absolute agreement were calculated, as a measure for inter-observer agreement of study selection. In case of disagreement between observers, a consensus was reached by means of discussion. In case of doubt, the publication was included in the next round of full-text assessment. All included full-text publications were retrieved from the library and were assessed for the same inclusion and exclusion criteria, by the same observers. Again, the inter-observer agreement was calculated using Cohen kappa and an absolute agreement.

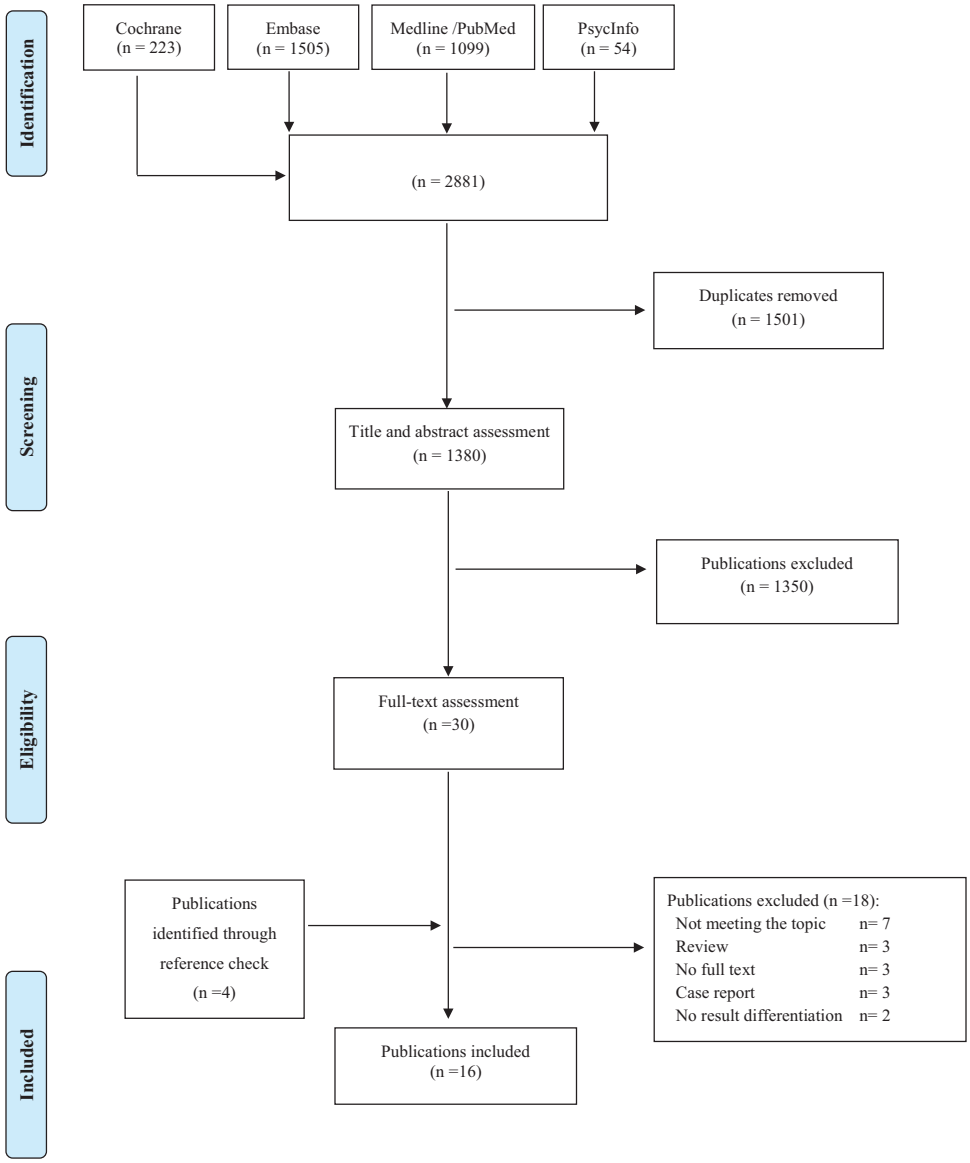

Figure 1. Flowchart of study selection.

References from the included studies were screened for additional relevant studies missed in the database search. These studies were assessed as described above.

All included studies were assessed according to 12 quality evaluation items:[13] report of source information, report of inclusion criteria, report of exclusion criteria, report of the time frame of recruitment, report of recruitment setting, subjects consecutively recruited, validated questionnaire, (patients were all analyzed, control or assessment of confounding, report of missing data, missing data imputed, and report of response rate. Each item was scored "1" if the criterion item was met, and "0" if the criterion item was not met.

Two reviewers (GW and PD) independently assessed the quality of the included studies. In a consensus meeting the scores were compared. When there was disagreement, a consensus was reached by means of discussion. In case of persistent disagreement, a third reviewer (JG) gave the final judgment. Again, Cohen kappa and absolute agreement were calculated.

3. Results

Searches yielded a total of 2881 publications (Fig. 1).

After removing duplicates, 1380 publications were assessed in the first selection. In total 1350 publications were excluded because they did not meet the inclusion criteria, leaving a total of 30 publications. Reviewing the reference lists of these 30 publications resulted in 4 additional publications. In total, 18 publications were excluded because they were either not meeting the topic, were reviews, case reports, did not differentiate between Lisfranc and Chopart amputations, or no full text was available (Fig. 1). The remaining 16 studies were included in this systematic review (Table 1). During the assessment of the publication, it was never necessary to consult the third assessor.

The inter-observer agreement expressed as Cohen kappa of the title and abstract assessment was 0.89 with an absolute agreement of 0.99, and 0.94 with an absolute agreement of 0.97 after the full-text assessment. After assessing study quality, the Cohen kappa was 0.91, with an absolute agreement of 0.88.

3.1. Study and patient characteristics

Only 1 of the 16 included studies had a prospective design.[15] The remaining studies were retrospective studies. Most patients were amputated because of diabetes mellitus (DM), and trauma, including industrial crush or blast accidents. In all studies, there was a predominance of men. The mean age ranged from 6.8 to 71.4 years (Table 1).

3.2. Quality assessment of the included studies

The quality of the included studies was weak. From the 12 methodological items assessed in the quality assessment, a median of 4.5 (interquartile range: 3; 5) was scored "positive." Only 2 studies had a score of 9 and 8 out of 12,[14,17] and 6 studies scored lowest with only 1 to 3.[15,16,21,22,25,26] Especially, validation of questionnaires, whether all patients were analyzed, whether confounding has been assessed or controlled for, and if missing data was imputed were hardly reported (Table 2).

3.3. Wound healing and the need for re-amputation

Fifteen studies described wound healing after Lisfranc or Chopart amputation.[2,6,14–22,24–27]

In total results of 61 Lisfranc, 229 modified Chopart, and 61 conventional Chopart amputations, with a total of 349 patients (in 2 patients a bilateral amputation was performed) were reported (Tables 1 and 3).

Modified Chopart amputation concerned either a single Achilles tenectomy,[17,21,22] ankle arthrodesis with Achilles tenectomy,[18] or conventional latissimus dorsi myocutaneous flap, or conventional latissimus dorsi myocutaneous flap combined with a serratus anterior muscle flap,[16] a reconstruction with latissimus dorsi or anterolateral thigh flap followed nu tibiotalocalcaneal arthrodesis,[14] or reconstruction with free medial plantar flap.[20]

One recent study[15] described a new surgical management protocol for symmetrical peripheral gangrene (SPG), which is a rare but devastating complication characterized by symmetrical ischemic change of the distal extremities often leading to amputation. They performed 2 Lisfranc amputations with skin and soft tissue reconstructions with thoracodorsal artery perforator-free flaps. One of the 2 Lisfranc amputations healed immediately but developed a chronic ulcer, the other Lisfranc amputation had partial necrosis as an early complication but healed properly over time.

Regarding the other Lisfranc amputations, the majority of the studies revealed satisfactory wound healing. Failure of wound healing was seen in 20% (12/61), which were converted to either Syme, trans-tibial, or trans-femoral amputation levels.[6,19,24,25]

In 28% (60/225) of the modified Chopart amputations, wound healing failed. Wound healing problems mainly concerned wound breakdown, remaining infection, ulceration, or re-ulceration with or without painful callus formation at a later stage,[14,16–18,22] or failure because of revascularization problems.[21] Most of the vascularization problems occurred in an early stage after amputation.[21] One study described a wound healing failure of 37% (17/46) leading to eventually 16 re-amputations to either Syme, Pirogoff, or trans-tibial amputation level,[22] while another study showed a 43% failure.[17] In a small study (n = 8), a modified Chopart reconstruction with a conventional latissimus dorsi flap combined with a serratus anterior flap was applied.[16] Another small study with 4 patients reconstructed the stump with a free medial plantar flap.[20] All patients received this double padding reconstruction,[16] or reconstruction with a free medial plantar flap[20] of which they healed without complications and did not need a re-amputation. These findings suggest that reconstruction, after a modified Chopart amputation, with flaps should be considered when primarily there is no sufficient soft tissue coverage of the amputation stump possible.

Finally, 46% (28/61) had a failure of wound healing after a conventional Chopart amputation.[2,24–27] Re-amputations were all converted to a Syme amputation. Multiple residual limb defects led sometimes to 50 to 60% of wound healing problems in the analyzed patients.[24,27] Brown et al,[2] described 60% (6/10) of the analyzed patients needing a re-amputation after 2.3 years of the initial conventional Chopart amputation. The reasons were not further specified.

Overall the studies reported heterogeneously regarding wound healing and the need for re-amputation per etiology. In the studies that specified wound healing problems and re-amputation per etiology, it was found that 40% (6/15) of the patients with wound healing problems after Lisfranc amputation had DM,[6,19] while 25% (6/24) were trauma patients.[24,25]

After a modified Chopart amputation, 37% (55/147) DM patients,[16–18,21,22] and 33% (7/21) trauma patients had wound healing problems.[14,16,18] The conventional Chopart amputation was predominantly performed in trauma patients. Of these trauma patients, 56% (22/39) had wound healing problems.[24–27] Patients with DM and a conventional Chopart amputation showed 44% (7/16) of wound healing problems.[2,26]

3.4. Level of function and ambulation

Thirteen studies described ambulation levels after Lisfranc or Chopart amputation.[2,6,14,15,17,18,20–23,25–27]

Table 1

Patient and study characteristics.

Author (yr)	Type of study	Number of amputations and patients	Data collection	Amputation etiology (number of patients)							Male/female ratio	Age mean (yr) And range (yr)	Time since amputation/follow up mean (range)	Other amputation levels studied
				Trauma	Vascular	Diabetes	Infection	Tumor	Congenital	Other/ unknown				
Chiu 2018[14]	R	12 Chopart§	CR, PE	5						7‡	9/3	38.6 (26–55)	18.7 mo (13–28)	
Lim 2018[15]	P	2 Lisfranc#	PE, PI, patient follow up							2†	1/1	60	54 and 12 mo	Trans-metatarsal
Kim 2016[16]	R	8 Chopart§	CR	3	1	4					6/2	52.1	–	Ray amputation, trans-tibial amputation, trans-femoral amputation
Faglia 2016[17]	R	83 Chopart§	PE, CR			83¶					57/26	71.4	2.8 yr	
Krause 2013[18]	R	17 Chopart§	PI, CR, Radio	6		9		2			12/5	54.6	–	
Brown 2012[2]	R	10 Chopart	CR, Q, PI, TI			10					–	56.8	–	Trans-metatarsal, trans-tibial amputation, and calcanectomy
Zgonis 2005[19]	R	8 Lisfranc	CR			8					–	–	–	Interphalangeal, metatarsal phalangeal, partial ray resection, and trans-metatarsal
Isik 1998[20]	R	4 Chopart§	CR, PE	4‖							4/0	20–24	(6 mo–2 yr)	
Chang 1994[21]	R	14 Lisfranc 59 Chopart§	CR, PE, PI		x	x					42/31	68 (42–91)	35 mo (1–144 mo)	Pirogoff and Syme
Lieberman 1993[22]	R	46 Chopart§ 45 patients		1	7	36				1*	23/22	65.0 (6–91)	Average 30 mo (2 wk–120 mo)	
Sanders 1992[6]	R	7 Lisfranc 1 Chopart	CR, Radio			6				2	–	–	–	Trans-metatarsal
Blanco 1990[23]	R	11 Chopart	CR, Q, PE						11		6/5	6.8	(1.9–18.6 yr)	
Millstein 1988[24]	R	20 Lisfranc 23 Chopart	CR, Q, PE							43‡	43/0	33 (15–63)	16 yr (1–68)	Trans-metatarsal, digital level
Lange 1984[25]	R	4 Lisfranc 4 Chopart	–	8							–	–	–	
Christie 1980[26]	R	6 Lisfranc 6 Chopart	CR, PI, PR	x		x				x*	4/2 Chopart Lisfranc not specified	–	(6 mo–30 yr)	Syme, trans-tibial
Lindqvist 1966[27]	R	6 Chopart 5 patients	PI, PE	5							4/1	20–60	(1–25 yr)	Pirogoff and Syme

– = not mentioned or not specified in article, CR = chart review, P = prospective study, PE = physical examination, PI = patient interview, PR = personal recollections, Q = questionnaire, R = retrospective study, Radio = radiological follow up, TI = telephone interview, x = not further specified.

* Patient with frostbite.

† Symmetrical peripheral gangrene (SPG).

‡ Industrial crush accident.

§ Modified Chopart amputation concerned either a single Achilles tenectomy (Faglia, Chang, Lieberman), ankle arthrodesis with Achilles tenectomy (Krause), a conventional latissimus dorsi myocutaneous flap or conventional lattisimus dorsi myocutaneous flap combined with a serratus anterior muscle flap (Kim), a reconstruction with latissimus dorsi flap or anterolateral thigh flap followed by tibiotalocalcaneal artrodesis (Chiu), or a reconstruction with free medial plantair flap (Isik).

‖ Mine explosion injury.

¶ All patients had diabetes with foot infections.

Lisfranc amputation with skin and soft tissue reconstruction with thoracodorsal artery perforator-free flaps with or without latissimus dorsi flap as a result of SPG.

Table 2

Study quality assessment.

Quality item study	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	Sum +
Chiu 2018[14]	+	+	+	+	+	+	+*	+	–	+	–	–	9
Lim 2018[15]	–	–	–	+	–	+	–	–	–	–	–	–	2
Kim 2016[16]	+	+	–	+	–	–	–	–	–	–	–	–	3
Faglia 2016[17]	+	+	–	+	+	+	–	+	+	–	–	+	8
Krause 2013[18]	+	+	–	+	–	+	+	?	–	–	–	–	5
Brown 2012[2]	+	+	–	+	–	?	+	?	+	–	–	–	5
Zgonis 2005[19]	+	+	+	+	–	?	–	?	–	–	–	–	4
Isik 1998[20]	–	–	–	–	+	+	NA	+	–	+	–	NA	4
Chang 1994[21]	+	–	–	–	–	?	–	?	–	–	–	–	1
Lieberman 1993[22]	–	–	–	+	–	?	–	–	–	+	–	+	3
Sanders 1992[6]	+	+	–	+	+	+	–	?	–	–	–	–	5
Blanco 1990[23]	+	+	+	+	–	?	–	?	–	–	–	–	4
Millstein 1988[24]	+	+	+	–	+	?	–	–	–	+	–	+	6
Lange 1984[25]	–	–	–	–	+	?	–	?	–	–	–	–	1
Christie 1980[26]	–	–	–	–	+	?	NA	–	–	–	–	NA	1
Lindqvist 1966[27]	+	+	–	+	+	?	–	?	–	–	–	+	5
Sum +	12	11	4	12	9	7	2	3	2	4	0	4	

Question: 1. Is the source of information reported? 2. Were inclusion criteria reported? 3. Were exclusion criteria reported? 4. Was the time frame of recruitment reported? 5. Was the recruitment setting reported? 6. Were subjects consecutively recruited? 7. Has the questionnaire been tested for measurement properties? 8. Have all patients been analyzed? 9. Has confounding been assessed and controlled for? 10. Were missing data reported? 11. Were missing data imputed? 12. Was response rate reported?

+ = Yes, – = No, ? = not described, NA = not applicable.

* one questionnaire was, the other 2 were not.

In total, they reported results concerning 33 Lisfranc, 221 modified Chopart, and 38 conventional Chopart amputations (Tables 1 and 3).

Three studies used a functional scale to determine the level of function or ambulation, namely the AmpuPro scale,[18] the Volpicelli ambulatory score,[2] or the functional ambulation classification (FAC),[15] by chart review or assessment of patients. The other 8 studies assessed the functional or ambulation outcomes per patient or used a gross functional description.

After reconstruction of the skin and soft tissue after a Lisfranc amputation because of SPG,[15] the 2 patients ambulated either on level surfaces with some supervision (FAC 4) or fully independently on level surfaces (FAC 5). Both of the patients were not able to ambulate on unlevel surfaces.

Regarding the other Lisfranc amputations, 85% (29/33) of patients was able to walk small distances without the use of a prosthesis or had good functional residual limb with no noticeable limp while walking with a prosthesis.[6,15,21,25,26] Within a period of 6 months, 12% (4/33) had some degree of equinus deformation.[6] One trauma patient had recurrent skin problems, leading to frequent maintenance of the provided prosthesis.[25]

After a modified Chopart amputation 74% (164/221) of all patients were able to walk without prosthesis for short or long distances.[14,17,18,20–22] One study used the AmpuPro score for assessing pain, activities in daily life, and prosthesis handling, with a maximum score of 120 points.[18] From the 17 analyzed patients with modified Chopart amputation the mean AmpuPro score was 107 (maximum score is 120), with an average loss of 0.9 points compared to the preexisting situation. However, all patients were able to walk comfortably without the prosthesis on soft ground for short distances. One study described 32% (15/47) re-ulceration after initial healing of the residual limb, which healed through conservative care.[17] Faglia et al[17] reported that only 2 of the 83 analyzed patients developed equinus deformity of the residual limb after modified Chopart amputation. Another study reported equinus deformation in 2 of the 46 analyzed patients.[22]

After a conventional Chopart amputation, 26% (10/38) had unlimited household ambulation measured with the Volpicelli ambulatory score.[2] For long distances, the majority of patients used a prosthesis.[2,6,27] These prostheses or orthoses were custom-made plastic prostheses,[27] custom-made Clamshell prostheses,[6] slipper-style prostheses with toe fillers, or ankle foot orthoses with footplate and shoe filler.[23] Five out of the 38 (16%) patients with conventional Chopart amputation had residual limb problems, problems with the fitting of the prostheses, or developed an equinus deformity.[6,26,27]

3.5. Lisfranc and Chopart amputations compared to a more proximal amputation level

Six studies compared amputation levels more proximal than the Lisfranc and Chopart amputation.[2,15,16,21,26,27] These concerned 17 partial and 16 total calcanectomy,[2] 8 trans-metatarsal amputations,[15] 21 Pirogoff,[21,27] 22 Syme,[21,26,27] 34 trans-tibial amputations,[2,16,26] and 2 trans-femoral amputations.[16] These were compared to 22 Lisfranc amputations,[15,21,26] 67 modified Chopart amputations,[16,21] and 22 conventional Chopart amputations.[2,26,27]

Thirty-five percent (6/17) and 31% (5/16) of the partial and total calcanectomy led to a re-amputation, compared to a 60% (6/10) re-amputation rate after a modified Chopart amputation.[2,16]

Lim et al[15] compared Lisfranc amputations with trans-metatarsal amputations using both types of amputation a wound reconstruction with thoracodorsal artery perforator-free flaps because of SPG. This procedure resulted in 75% (6/8) healing without complications after trans-metatarsal amputation, compared to 50% (1/2) after Lisfranc amputation. Twenty-five percent (2/8) had partial necrosis after trans-metatarsal amputation, compared to 50% (1/2) after Lisfranc amputation. Late complications were either chronic osteomyelitis (1/8) or chronic ulcer (1/2) after Lisfranc amputation.

Lindqvist et al[27] described a 100% (4/4) good residual limb formation after Pirogoff amputation, and 72% (8/11) good residual limb formation with a Syme amputation, compared to a 50% (3/6) after conventional Chopart amputation. Another study[21] showed a 29% (5/17) early failure after Pirogoff amputation, and a 13% (1/8) early failure after Syme amputation, compared to no failures after Lisfranc amputation, and 12% (7/59) after modified Chopart amputation. All failures led to re-amputations, but levels were not specified. They reported that overall no significant differences were seen in the frequency of failures between the different types of amputations. The

Table 3

Study outcomes.

Author (pub yr)	Number of patients and type of amputation	Wound healing	Re-amputation level	Level of functioning and ambulation
Chiu 2018[14]	12 Chopart*	3/ initial 5 infection 7/7 no infection 1/12 delayed wound healing 1/12 marginal necrosis of flap	1/12 to TTA	11/12 Full weight-bearing stump and no prosthesis use 1/12 Walking outdoors with restriction 10/12 Walking outdoors without restriction
Lim 2018[15]	2 Lisfranc†	1/2 chronic ulcer 1/2 early problems but healed eventually proper	None	1/2 With chronic ulcer walked independently on level surfaces only 1/2 Walked dependent with walking aid and supervision
Kim 2016[16]	8 Chopart*	3/8 healed 5/8 failed	1/8 to proximal bony amputation, not further specified	Not reported
Faglia 2016[17]	83 Chopart*	47/83 healed 23/83 failed 13 died	13/23 TTA 10/23 TFA	2/83 Equinus deformity 15/47 Ulcer recurrence, completely healed with conservative care Able to walk on residual limb without prosthesis, distance not further specified
Krause 2013[18]	17 Chopart*	8/17 minor problems 4/17 early breakdown 9/17 late problems	Not reported	Mean AmpuPro score of 107 (maximum score 120 points) Average loss of 0.9 points on the AmpuPro scale after amputation 17/17 Were able to walk without prostheses on soft ground for short distances.
Brown 2012[2]	10 Chopart		6/10 after a mean of 2.3 years (not specified)	Chopart: mean Volpicelli ambulatory score of 4.3 ± 2.9 (unlimited household ambulation)
Zgonis 2005[19]	8 Lisfranc	5/8 healed 3/8 failed	Not reported	Not reported
Isik 1998[20]	4 Chopart*	4/4 primary wound healing problems, after reconstruction no problems anymore	None	Walked long distances with foot prosthesis
Chang 1994[21]	14 Lisfranc 59 Chopart*	14/14 Lisfranc healed 7/59 Chopart early failure 3/59 Chopart late failure	Lisfranc no re-amputation 10/59 Chopart were converted to proximal amputation level (not specified)	With Lisfranc and Chopart amputations patients were able to walk small distances without prosthesis
Lieberman 1993[22]	46 Chopart*	11/46 excellent healing 13/46 good healing 5/46 multiple problems 17/46 failed	16/17 were converted to TTA (8), Syme (2), or Pirogoff (2). The other 4 are unknown.	2/46 Equinus deformity 11/46 Prosthesis without discomfort 13/46 Prosthesis with occasional minimal discomfort 5/46 Prosthesis with mild to moderate discomfort of which 4 were community ambulators
Sanders 1992[6]	7 Lisfranc 1 Chopart	4/7 Lisfranc healed 3/7 Lisfranc failed 1/1 Chopart healed	3 failed Lisfranc converted to Syme, TTA, and TFA Chopart no re-amputation	4/7 Lisfranc some degree of equinus deformity within 6 months 4/7 Lisfranc, satisfactory ambulation 1/1 Chopart developed equinus deformity with plantar ulceration 1/1 Chopart, ambulation with custom-made clamshell prosthesis with a limp and shorter steps

(*Continued*)

Table 3

(*Continued*)

Author (pub yr)	Number of patients and type of amputation	Wound healing	Re-amputation level	Level of functioning and ambulation
Blanco 1990[23]	11 Chopart	–	None	No equinus deformity or callosities No functional limitations No prosthesis use or pain with household ambulation
Millstein 1988[24]	20 Lisfranc 23 Chopart	7/20 Lisfranc good healing 7/20 Lisfranc end-result 1/20 Lisfranc poor end-result 6/23 Chopart good healing 3/23 Chopart fair end-result	5/20 Lisfranc converted to Syme 14/23 Chopart converted to Syme	Not reported
Lange 1984[25]	4 Lisfranc 4 Chopart	1/4 Lisfranc ulceration of skin graft 4/4 Chopart inadequate anterior skin coverage	1/4 Lisfranc converted to Syme 4/4 Chopart converted to Syme	3/4 Lisfranc amputation had a functional foot 1/4 Lisfranc amputation, participation in recreational sports, wearing high-top shoes with toe filler 1/4 Lisfranc amputation wore prosthesis which required frequent maintenance because of skin problems
Christie 1980[26]	6 Lisfranc 6 Chopart	1/6 Chopart slow wound healing	None (Lisfranc and Chopart)	6/6 Lisfranc satisfied with stump, could walk on bare stump, and showed unrestricted walking 1/6 Chopart disabling equinovarus deformity 2/6 Extremely active; unrestricted outdoor activities 2/4 Active, not further specified
Lindqvist 1966[27]	6 Chopart of which 1 bilateral	3/6 healed 3/6 failed	Not reported	2/6 Problem-free concerning stump and prosthesis 1/6 Had 1 major defect concerning functioning residual limb and prosthesis 3/6 Several defects concerning functioning residual limb and prosthesis 3/5 Chopart amputees were totally dependent on their prosthesis

Modified Chopart amputation concerned either a single Achilles tenectomy (Faglia, Chang, Lieberman), ankle arthrodesis with Achilles tenectomy (Krause), or a conventional latissimus dorsi myocutaneous flap or conventional lattisimus dorsi myocutaneous flap combined with a serratus anterior muscle flap (Kim), a reconstruction with latissimus dorsi flap or anterolateral ticht flap followed by tibiotalocalcaneal artrodesis (Chiu), or a reconstruction with free medial plantair flap (Isik).

TFA = trans-femoral amputation, TTA = trans-tibial amputation.

*Modified.

† Lisfranc amputation with skin and soft tissue reconstruction with thoracodorsal artery perforator free flaps with or without latissimus dorsi flap as a result of symmetrical peripheral gangrene.

re-amputation rate after trans-tibial amputation was described by 2 studies,[2,16] which described a 9% (3/33) failure leading to re-amputation, compared to the 60% (6/10) re-amputation rate of the analyzed conventional Chopart amputations,[2] and 12.5% (1/8) after modified Chopart amputation.[16]

Two of the 4 above-mentioned studies reported on ambulation.[21,27] Chang et al[21] reported that patients with Lisfranc and modified Chopart amputations were able to walk without prosthesis for short distances, more easily than patients with a Pirogoff or Syme amputation. Lindqvist et al[27] showed a 100% (4/4) good functional residual limb of the Pirogoff amputation, 82% (9/11) of the Syme amputation, compared to 33% (2/6) good functional residual limb after conventional Chopart amputation.

4. Discussion

To the best of our knowledge, no systematic review has been published on various outcomes after Lisfranc and Chopart amputation. We, therefore, aimed with the present review to find evidence for the pros and cons concerning wound healing, the need for re-amputation, equinus deformity, and ambulation after Lisfranc or Chopart amputation.

Sixteen studies were included. The publication dates ranged from 1966 to 2018. The reported data of these studies were heterogeneous and often poor in quality, making it difficult to compare results and impossible to perform a meta-analysis.

However, our review did show that 20% of the Lisfranc amputations resulted in a more proximal re-amputation. After a modified Chopart and conventional Chopart amputation, 28% and 46%, respectively, resulting in a more proximal amputation. These data suggest that the Lisfranc amputation has a better outcome concerning wound healing than both types of Chopart amputation. However, these data could be confounded by indication.

Comparing wound healing and re-amputations after Lisfranc and Chopart versus more proximal levels of amputation, the number of patients studied was too small to find significant differences in the studies, as the authors stated themselves. Further investigation is therefore needed. Related to the etiology of the Lisfranc amputation we found 40% of the patients with DM and 25% of trauma patients had wound healing problems. After a modified Chopart amputation 37% of the DM patients and 33% of the trauma patients had wound healing problems. After a conventional Chopart amputation, wound healing problems were seen in 36% of the patients with DM and 58% of trauma patients. These problems could be secondary to the severity of the underlying varying vascular disease in these patients or the severity of trauma. In a recent retrospective study, it was shown that re-amputation after amputation for diabetic foot ulcers was associated with a higher level of serum HbA1c, suggesting that this value may predict re-amputation in diabetic patients.[28] However, not all studies reported on the vascular or trauma status of the studied patients in our review, so no definitive conclusions can be drawn at this point.

Despite several precautions involving, revascularization procedures and prevention of equinus deformation by Achilles tenectomy, the re-amputation rate after Lisfranc and modified Chopart amputation is relatively high. One study[16] showed a trend towards a more effective reconstruction of the stump, preventing re-amputation when using double padding with a latissimus dorsi flap combined with a serratus anterior flap. Another, 2 studies showed a tendency towards better results after prioritizing soft tissue coverage (with different techniques) over bony procedures to prevent infections and have better stump formation.[14,20] Additionally, a recent study has shown the development of a new surgical technique, called "Green modification" to provide a sound and functional Chopart amputation. They utilize a balanced tendon transfer of the tibialis anterior, extensor hallucis longus, and extensor digitorum longus tendons, along with a gastrocnemius recession and/or isolated Achilles tenotomy.[12]

Besides surgical modifications to induce proper wound healing after Chopart amputation, a new interim off-loading orthosis can be considered for patients with diabetes.[29] However, because of the given heterogeneity of patient characteristics, the low number of patient groups, vascular diversity, and the heterogeneous quality of the studies, definitive overall conclusions cannot be drawn.

When analyzing the equinus deformity of the residual limb after Lisfranc or Chopart amputation, the results were poorly investigated. The majority of the included studies, however, did perform a modified Chopart amputation to prevent equinus deformation. Whether it actually resulted in the less frequent occurrence of the deformities was, unfortunately, not described. Only 4 studies revealed that just a few of the Lisfranc and modified Chopart amputations led to some degree of equinus of the residual limb.[6,17,22,26] However, the number of patients studied was too small to contribute to the debate concerning efficacy and concerns about the higher incidence of complications of especially the Chopart amputation.[30,31]

Analyzing the ability to ambulate revealed that persons with Lisfranc and Chopart amputations both had the ability to walk short distances without prostheses, an advantage above a trans-tibial amputation. Concerning the problems with the prosthesis, results varied. Especially the older studies[22,27] reported fitting problems of the Chopart prosthesis, while studies of a more recent date did not. The majority of the patients after Lisfranc or Chopart amputation remained having the ability to ambulate well enough in daily living. A few were even participating in high-level impact ambulation. Although some studies state that a trans-tibial amputation can be functionally better than a Lisfranc or Chopart amputation,[2,32,33] our review shows, however, that a Lisfranc and Chopart amputation can be an advantage in offering a functional residual limb and the ability of continuous ambulation without prosthesis.

Additionally, 2 studies, not described in this review because of the lack of differentiation of their results, showed encouraging results of performing a Lisfranc or Chopart amputation before performing a more proximal amputation. Elsharawy et al[34] described wound healing results for 24 Lisfranc and 8 conventional Chopart amputations. Eight of the remaining 30 patients (2 died) had wound healing problems which led to a trans-tibial amputation. Sixty-seven percent (20/30) could ambulate well enough with the use of a prosthesis. Roach et al[35] showed results of 19 patients after a Lisfranc or a conventional Chopart amputation which led to good functional stumps with could ambulation performances in 95% (18/19).

The present review has a few limitations. First, most included studies were retrospective in design with a variety of reported data. As mentioned before, this resulted in a heterogeneous study population, making generalization to larger and other populations impossible. In addition, studies included relatively small numbers of patients. Only 3 studies included >35 patients,[17,21,22] limiting generalization as well. Finally, because of the small numbers of patients in the studies and the lack of detailed reporting, except for 3 recent studies,[14,16,17] a patient profile leading to ensure physicians a positive outcome after a Lisfranc or Chopart amputation cannot be drawn. A similar conclusion was drawn after reviewing the literature regarding trans-metatarsal amputations.[36]

5. Conclusion

The need for re-amputation because of wound healing problems seems to occur quite often, especially after conventional Chopart amputation. When considering a Chopart amputation,

the modified Chopart shows a trend towards the best outcome concerning wound healing and re-amputation rate compared to a conventional Chopart amputation. However, although the total number of patients is low, Lisfranc amputation does seem to favor both types of Chopart amputation. Lisfranc and both Chopart amputations provide patients with a functional residual limb, with the remaining ability to ambulate without prosthesis for short distances.

Future studies with larger numbers of included patients are needed to identify patient possible characteristics to predict favorable outcomes of Lisfranc and Chopart amputation. In addition, future studies with a longer follow-up period are needed to provide further, and more recent, reports of outcome measures like wound healing, equinus deformity, and re-amputation rates after Lisfranc and Chopart amputation.

Author contributions

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