REVIEW

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Ray Amputation *vs* Finger Amputation: a Systematic Review

F. Oliva[1,2], G. Gargano[1,2], M. Quaranta[1,2], E. Piccirilli[3,4], N. Maffulli[1,2,5,6]

[1] *Department of Musculoskeletal Disorders, Faculty of Medicine and Surgery, University of Salerno, Baronissi, Salerno, Italy*
[2] *Orthopaedic Clinic, San Giovanni di Dio e Ruggi D'Aragona Hospital, Salerno, Italy*
[3] *Department of Clinical Sciences and Translational Medicine, University of Rome Tor Vergata, Rome, Italy*
[4] *Department of Orthopedics and Traumatology, Policlinico Tor Vergata (PTV) Foundation, Rome, Italy*
[5] *Queen Mary University of London, Barts and the London School of Medicine and Dentistry, Centre for Sports and Exercise Medicine, Mile End Hospital, London, U.K.*
[6] *Faculty of Medicine, School of Pharmacy and Bioengineering, Guy Hilton Research Centre, Keele University, Stoke-on-Trent, U.K.*

CORRESPONDING AUTHOR:
Francesco Oliva
Department of Musculoskeletal Disorders
Faculty of Medicine and Surgery
University of Salerno
via Salvador Allende 43
84084 Baronissi
Salerno, Italy
E-mail: olivafrancesco@hotmail.com

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SUMMARY

Background. In some instance, finger amputation is required. The surgery may involve only the amputation of a finger (finger amputation) of an entire ray (ray amputation). We wished to better define the functional results of finger and ray amputation

Sources of data. A systematic search of different databases was performed to November 2021 to compare ray amputation *vs* finger amputation. Twenty suitable studies were identified.

Areas of agreement. This systematic review compares ray amputation and finger amputation to highlight differences in the outcome relating to cosmetic and functional aspects, residual strength and return to activity.

Areas of controversy. Many authors have described the results of ray amputation and finger amputation for a variety of different pathologies. It is therefore difficult to separate the underlying pathology from the cosmetic and functional result that could contribute to the dissatisfaction of the treatment used.

Growing points. The treatments used could be differentiated according to the underlying pathology and the condition of the finger to be treated

Areas timely for developing research. To date, it is not possible to determine the best treatment in relation to the patient's pathology.

KEY WORDS

Ray amputation; ray resection; ray surgery; finger amputation; finger resection; finger surgery; hand surgery; hand pathology.

INTRODUCTION

The human hand is anatomically located distal to the wrist, and consists of the palm and fingers. The metacarpus is the bony component of the palm, and the phalanges represent the bony component of the fingers. The five fingers are the continuation of the metacarpal bones and each has a specific name. The first radial finger is the thumb; the other fingers, in the radio-ulnar direction, are the index, middle, ring and little finge .

Given the role of the hand, trauma or other pathological conditions may cause considerable discomfort, especially when finger amputation is unavoidable.

In most cases, amputation is the result of acute traumatic injuries in which it is not possible to save the finger (1, 2). Less often, the amputation is performed as an elective procedure for the management of complications related to previous trauma, such as infections and neuromas (3). Other causes include cancer (4) and Dupuytren's disease (5).

The functional outcome is strongly related to the finge involved. The greatest difficulties are encountered in thumb amputation, while, in amputation of the other fingers, there is a greater possibility of adaptation (1)
When finger amputation is associated with amputation of the corresponding metacarpal, thus performing a ray amputation, the hand function can paradoxically be less compromised (6).
A major advantage of ray amputation over finger amputation is the cosmetic result. Indeed, with amputation of an intermediate ray, in particular when the middle and ring fingers are involved, it is possible to bring the two adjacent rays to the removed one closer, thus restoring at least part of the appearance of the hand; furthermore, the transposition of the adjacent rays allows to avoid complications such as malrotation (7).
The present systematic review compares ray amputation and finger amputation to highlight differences in the outcome relating to the cosmetic and functional aspect, residual strength and return to activity.

METHODS

The present systematic review was performed following the Preferred Reporting guidelines for systematic reviews and meta-analyses (PRISMA) (**figure 1**) (8).
A systematic search up to November 2021 of articles assessing the surgical outcome of a single finger amputation versus single ray amputation with no restrictions of language was performed.
In the search, we used combinations of the following key terms: ray amputation, finger amputation, hand, resection, with no limit of year of publication.
We excluded editorials, abstracts, technical notes, conference presentations, narrative reviews, and expert opinions.
Two investigators independently conducted the systematic search, through November 2021, using full-text archives of Embase, Google Scholar, Scopus and PubMed. The titles and abstracts were examined separately by the two investigators to remove duplicates and evaluate the eligible studies according to the pre-defined inclusion criteria. The full text of each article was examined by both investigators if either of them perceived ambiguity, and the bibliographies of the articles included were reviewed by hand to identify further related articles. Where present, discrepancies were resolved through discussion with the senior investigator.
Twenty studies met the inclusion criteria and were included in the analysis. The PRISMA flowchart shows the details of the search (**figure 1**).

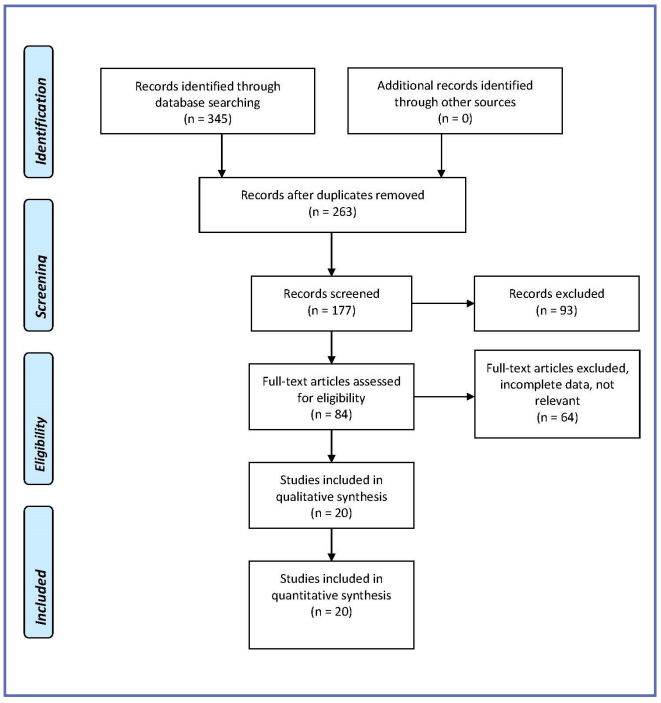

Figure 1. PRISMA Flow Diagram 2009.

RESULTS

Literature review

The first search on PubMed, Scopus and Google Scholar provided a total of 345 articles, which included 82 duplicates. Following reading title and abstract, 93 articles were excluded. Of the remaining 177 articles, 64 were not relevant. Finally, full text reading of the remaining 84 articles allowed to select 20 articles (**table I**).
This systematic review includes 363 patients. Ray amputation was performed in 332 (91.46%) patients with an average age of 38.34 years (SD 14.02; range from 11 to 83) and an average follow-up of 34.71 months (SD 25.22; range from 6 to 108); finger amputation was performed in 31 (8.54%) patients, with an average age of 47.65 years (SD 12.16; range from 32.5 to 83) and an average follow-up of 38.53 months (SD 8.22; range from 33.1 to 48) (**table II**).

Cosmetic satisfaction

Of the 332 patients who underwent ray amputation, 9.64% (32 patients) expressed an excellent opinion on the cosmetic result; 59.64% (198 patients) reported a good cosmetic result; 16.57% (55 patients) were satisfied; while only 0.30% (1 patient) of patients reported a poor cosmetic result.

Table I. Studies included.

Study (Authors)	Sample Size	Mean Age	Finger	Aethiology	Surgical Procedure	Follow-up (month)
O'Brien *et al.* (2016) (9)	1 M	34	Middle	Traumatic	1 Ray amputation	24
Bhat *et al.* (2017) (6)	37 M 8 F	36.6	10 Index 15 Middle 8 Ring 12 Little	24 Traumatic 5 Cancer 5 Infection 9 Others	45 Ray amputation	20
Roberts *et al.* (1977) (4)	4 M 9 F	51,6	1 Thumb 4 Index 2 Middle 1 Ring 5 Little	13 Cancer	8 Ray amputation 5 Finger amputation	48
Clayton *et al.* (1963) (10)	7	-	7 Index	7 Traumatic	7 Ray amputation	108
Degreef *et al.* (2009) (5)	22 M 5 F	61.5	1 Thumb 7 Index 1 Middle 5 Ring 9 Little	7 Traumatic 7 Dupuytren 13 Others	22 Ray amputation 5 Finger amputation	-
Gross *et al.* (1997) (11)	7 M 4 F	13.5	-	11 Sarcoma	3 Ray amputation	66
Karle *et al.* (2002) (12)	45 M 33 F	45	Index	-	58 Ray amputation 12 Finger amputation	33.1
Laborde *et al.* (1982) (3)	37 M 13 F	-	-	50 Neuroma post-traumatic	14 Ray amputation	-
Lyall *et al.* (1996) (13)	7 M 1 F	40	-	5 Traumatic 2 Cancer 1 Others	8 Ray amputation	24
Melikyan *et al.* (2003) (1)	14 M 6 F	52	8 Index 5 Middle 1 Ring 6 Little	14 Traumatic 2 Cancer 2 Dupuytren 2 Others	20 Ray amputation	-
Monreal *et al.* (2017) (14)	6 M 3 F	30.3	9 Ring	9 Traumatic	9 Ray amputation	17.1
Peimer *et al.* (1999) (15)	18 M 7 F	28	-	24 Traumatic 1 Cancer	25 Ray amputation	-
Puhaindran *et al.* (2010) (16)	16 M 9 F	48.8	7 Index 5 Middle 6 Ring 7 Little	25 Cancer	25 Ray amputation	11
Sadek *et al.* (2015) (17)	19 M 6 F	34	25 Ring	25 Traumatic	25 Ray amputation	28
Sood *et al.* (2000) (18)	1 M	60	1 Middle	1 Traumatic	1 Ray amputation	-
Iselin *et al.* (1988) (7)	12	-	12 Ring		12 Ray amputation	37
Nuzumlali *et al.* (2003) (2)	15 M 8 F	32,5	23 Ring	23 Traumatic	14 Ray amputation 9 Finger amputation	34,5
Segret *et al.* (2008) (19)	8 M 3 F	35	11 Ring	11 Traumatic	11 Ray amputation	9
Steichenet *et al.* (1986) (20)	10 M 3 F	38	4 Middle 9 Ring	8 Traumatic 5 Others	13 Ray amputation	43
J-G Delvaque *et al.* (2021) (21)	8 M 3 F	11	3 Middle 8 Ring	11 Traumatic	11 Ray amputation	18

Table II. Summary results.

	Ray amputation	Finger amputation
Number of patients	332	31
Age (mean; range)	38.34 (13.5 to 83)	47.65 (32.5 to 83)
Follow-up (months, range)	34.71 (6 to 108)	38.53 (31.1 to 48)
Cosmetic satisfaction number (%)		
excellent	32 (9.64%)	-
good	198 (59.64%)	5 (16.13%)
satisfactory	55 (16.57%)	-
poor	1 (0.30%)	9 (29.03%)
no data	46 (13.85%)	17 (54.84%)
Function satisfaction number (%)		
satisfactory	264 (79.52%)	17 (54.84%)
poor	20 (6.02%)	0
no data	48 (14.46%)	14 (45.16%)
Strength loss (mean; %; range)	27.38% (17 to 34)	18.4%
Return to Activity (number of patients)	Yes: 166 (50.00%) No: 4 (1.2%) No data: 162 (48.8%)	Yes: 9 (29.03%) No: 0 No data: 22 (70.97%)
Return to Activity (weeks)	14.2	9.9

Of the 31 patients who underwent finger amputation, no excellent opinion on the cosmetic result was reported; 16.13% (5 patients) reported a good cosmetic result; 29.03% (9 patients) reported a poor cosmetic result. There are no data relating to the cosmetic appearance in the remaining 54.84% (17 patients).

Function satisfaction

79.52% (264 patients) undergoing ray amputation were satisfied with the functional result of the surgery; 6.02% (20 patients) reported functional deficits. The remaining 14.46% (48 patients) gave no data relating to the function.
54.84% (17 patients) of patients undergoing finger amputation reported being satisfied with the functional result. There are no data relating to the functional aspect in the remaining 45.16% (14 patients).

Strength

The aneroid type of sphygmomanometer was used to measure grip strength. In patients undergoing ray amputation, the average strength loss was 27.38% (17 to 34), while in patients undergoing finger amputation, the average strength loss was 18.4%.

Return to activity

Of the 332 patients who underwent ray amputation, 50% (166 patients) returned to their previous activities; 1.2% (4 patients) did not return to their previous activities.
Of the 31 patients who underwent finger amputation, 29.03% (9 patients) returned to their previous activities.
In patients who underwent ray amputation, the return to activity was 14.2 weeks, while for patients who underwent finger amputation, the time to return to activity was 9.9 weeks.

DISCUSSION

The hand combines prehension with sensory and communicative functions. Injuries, but also cancer, infections and other conditions can be the cause of amputation and produce considerable discomfort. Ray amputation is indicated in patients with irreparable damage to the proximal phalanx requiring complete finger amputation (15)
Ray amputation can be useful in cases of involvement of the index, both in cases of complete amputation and at the level of the proximal interphalangeal (PIP) joint; in these cases, the middle finger functionally replaces the index (22). When middle and ring fingers are involved, ray amputation is indicated to reduce hand deformity and improve function (1).

The complications related to the two surgical procedures were evaluated by a few authors; these were also evaluated differently in the relevant articles. Often, the evaluation is based on functional outcome and patients' satisfaction.
Among the complications, Bhat *et al.* (6) included gap and deformity, while Roberts *et al.* (4) assessed the complications in relation to the severity of the cancer treated.
The most significant functional and psychological complications are related to amputations in children (11).
Laborde *et al.* reported persistent post-surgical pain in 71% of patients (23).
Karle *et al.* reported pain in 65.5% of the patients after ray amputation, and in 91.7% after finger amputation (12).
Melikyan *et al.*, after ray amputation, reported persistent moderate to severe pain in 80% of patients (1). Other complications include reduced sensitivity in the adjacent fingers (4/25 patients) (15), 1 phantom hand, 8 psychological problems (19), 1/12 postoperative dystrophy(7), 2 digital neuromas, 1 lumbrical/interosseous adhesions, 1 scar contracture, 4 palmar tenderness, 4 intolerance to cold (20).
Amputating only the finger can produce some functional disadvantages in terms of object grip and cosmetic result. Indeed, after ray amputation all treated patients report good cosmetic and functional satisfaction. Surgical complications seem not to be very dissimilar between finger amputation and ray amputation.

Limitations

We acknowledge that none of the articles identified is a randomized trial. In addition, the number of patients identified is limited, and there is a lack of comprehensive patient data. In particular, we were not able to identify data on return to activity and size of defect in all the articles. In addition, the measurement of defects in the hand reported in the articles may be affected by errors from the subjective assessment of the examiner. Finally, there is no scoring system that allows to standardize outcomes.

CONCLUSIONS

Ray amputation appears to be preferred over finger amputation.
If an extensive amputation is to be performed, due to trauma, cancer or other conditions, ray amputation should be considered. Nevertheless, the literature does not provide precise indications on when to perform a ray amputation or finger amputation. The choice of the type of procedure is therefore left to the operating surgeons, based on their knowledge and the patient's conditions and expectations, taking into account the underlying pathology.

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DATA AVAILABILITY

The data underlying this article are available in the article.

CONTRIBUTIONS

GG, MQ: data collection, analysis, drafting of the manuscript. FO, NM: critical revision of the manuscript.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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