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Donor Finger Morbidity in Cross-Finger Flap: A Systematic Review and Meta-Analysis

Sourabh Shankar Chakraborty[1] Ranjit Kumar Sahu[2] Sudeshna Acharya[3] Akhil Dhanesh Goel[4] Manojit Midya[5] Suresh Kotu[6]

[1] Department of Burns and Plastic Surgery, All India Institute of Medical Sciences, Kalyani, Nadia, West Bengal, India
[2] Department of Burns & Plastic Surgery, All India Institute of Medical Sciences, Bhubaneswar, Odisha, India
[3] Department of Trauma & Emergency, Burdwan Medical College, Bardhaman
[4] Department of Community Medicine, All India Institute of Medical Sciences, Jodhpur, Rajasthan, India
[5] Plastic & Reconstructive Surgery Department, Government Medical College, Kota, Rajasthan, India
[6] Department of Burns and Plastic Surgery, GSL Medical College, Rajahmundry, Andhra Pradesh, India

Address for correspondence Ranjit Kumar Sahu, MS, MCh, FCLS, Department of Burns & Plastic Surgery, All India Institute of Medical Sciences, Room No-206, OPD building, Bhubaneswar 751019, Odisha, India (e-mail: plastic_ranjit@aiimsbhubaneswar.edu.in).

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Abstract

Background The morbidity of donor finger in a cross-finger flap has not received as much importance as the outcomes of the flap itself. The sensory, functional, and aesthetic morbidity of donor fingers, reported by various authors, are often contradictory to each other. In this study, objective parameters for the sensory recovery, stiffness, cold intolerance, cosmetic outcome, and other complications in the donor fingers, reported in the previous studies, are systematically evaluated.

Methods This systematic review is reported using Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) protocol and was registered with the International prospective register of systematic reviews (PROSPERO registration no. CRD42020213721). Literature search was done using "cross-finger," "heterodigital," "donor finger," and "transdigital" words. Data regarding demography, patients' number and age, follow-up duration and outcomes of donor finger, including 2-point discrimination, range of motion (ROM), cold intolerance, questionnaires, etc. were extracted from included studies. Meta-analysis was performed using MetaXL and risk of bias was evaluated using Cochrane risk of bias tool.

Results Out of the total 16 included studies, 279 patients were objectively evaluated for donor finger morbidity. Middle finger was most frequently used as donor. Static two-point discrimination seemed to be impaired in donor finger in comparison to contralateral finger. Meta-analysis of ROM suggested that statistically there is no significant difference in ROM of interphalangeal joints in donor and control fingers (pooled weighted mean difference: −12.10; 95% confidence interval: −28.59, 4.39; $I2 = 81\%$, $n = 6$ studies). One-third of donor fingers had cold intolerance.

Keywords
- cross-finger flap
- donor finger
- morbidity
- systematic review

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Conclusion There is no significant effect on ROM of donor finger. However, the impairment that seems to be in sensory recovery and aesthetic outcomes needs to be further evaluated objectively.

Introduction

Cross-finger flap, since its inception in 1950 by Gurdin and Pangman,[1] has proven its worth as a workhorse for various finger defect reconstruction. A plethora of literature is available, in which a number of variants and modifications of cross-finger flap have been successfully used for different kinds of finger reconstructions, with good functional, sensory, and aesthetic outcomes. However, morbidity of the donor finger had not received equal importance. Success of the cross-finger flap shall also depend intimately with the extent of donor finger morbidity. There are very few studies in which objective assessment of donor finger morbidity has been reported. Contradictory claims regarding the extent of donor finger morbidity have been described in literature ranging from none or minimal[2–6] to significant morbidity.[7,8] This has led to a gap in the current knowledge to guide the surgeon regarding postoperative morbidity in the donor finger. In this review, our primary objective was to estimate the sensory, functional, and aesthetic morbidity and the complications in the donor fingers of cross-finger flap. Our secondary objective was to determine the effects on the two-point discrimination (2-PD) and range of motion (ROM) of donor fingers, compared to the control fingers.

Materials and Methods

Search Strategy

This systematic review was registered with the International Prospective Register of Systematic Reviews (PROSPERO registration no. CRD42020213721), adhering to the standards of the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines. An electronic database search on PubMed, Google Scholar, and the Cochrane Library was conducted on November, 2020 using a combination of both Medical Subject Heading terms and plain text related to morbidity of donor finger of cross-finger flap. No restriction like language or publication date was used. The syntax used for search strategy are as follows:

PubMed: ("cross-finger flap") OR ("heterodigital") OR ("donor finger") OR ("transdigital")
Google Scholar: "cross-finger" OR "heterodigital" OR "donor finger" OR "transdigital" (excluding patents and citations)
The Cochrane Library: "cross-finger flap" in title abstract keyword OR "transdigital" in title abstract keyword OR "heterodigital" in title abstract keyword OR "donor finger" in title abstract keyword—(word variations have been searched).

The manuscripts were reviewed manually by two independent authors (SSC, RKS) to identify appropriate studies. Duplicate studies were removed. References of appropriate articles were also screened to identify additional related studies. In case of any discrepancy, a consensus was formed by mutual discussion with other reviewers (SA, ADG, MM, SK).

Eligibility Criteria

The inclusion criteria for the studies were based on the PICOT framework—participants, intervention, reference standard used for comparison, and outcomes (►**Supplementary Table S1**, online only). Those studies in which donor finger of cross-finger flaps were evaluated with at least one objective parameter (two-point discrimination, Semmes-Weinstein [SW] monofilament test, ROM at interphalangeal (IP) or metacarpophalangeal joints, visual analog scale, Michigan hand outcome questionnaire) were included for systematic review. No restriction on participant age or gender or demographic characteristic was used. The control group comprised the sensory, functional, and aesthetic scores of the contralateral finger, measured in terms of the mentioned objective parameters. Both retrospective and prospective studies and case–control studies were included. Studies in which sensory, aesthetic, and/or functional outcomes of donor finger were assessed unobjectively in the follow-up, or studies in which heterodigital flap reconstruction based on neurovascular pedicle (proper digital artery) was done were excluded.

Data Extraction

Two independent reviewers (SA, SK) extracted the data independently from the included studies in a standardized data extraction sheet using Microsoft Excel 2016. In case of any discrepancy, a consensus was formed by mutual discussion with other reviewers (SSC, RKS, ADG, MM). The data extracted included demographic details (author and year of publication, country of origin, type of study, level of evidence), population details (total number of patients, number of male and female patients, number of flaps done/followed up, patients' age), perioperative details (flaps performed, with any modifications, follow-up duration), sensory outcomes of donor and control fingers (questionnaire, 2-point discrimination, SW monofilament test), functional outcomes (ROM at IP joints or total range, stiffness), aesthetic outcomes (questionnaire, visual analog scale, pigmentation, contour deformity), and cold intolerance/ pain. Any additional objective outcomes were also reported.

Data Synthesis and Analysis

Two review authors (ADG, SSC) analyzed data. The weighted mean of each outcome was calculated based on sample sizes of each included study using the following method: (1) multiply the mean outcome of each study by the study

sample size, (2) sum the products to get the total value, (3) sum the sample sizes to get the total weight, and (4) divide the total value by the total weight to provide a weighted mean for each outcome. The meta-analysis was performed using the Microsoft Excel 2016, with MetaXL version 5.2, add-in software (developed by EpiGear International Pty Ltd, Queensland, Australia). The summary effect was ascertained using weighted mean difference (WMD) that was calculated using the inverse variance heterogeneity model. Heterogeneity was ascertained using the I squared statistic. Small study effects like publication bias were evaluated using the Doi plot and Luis Furuya-Kanamori (LFK) index. The Doi plot replaces the conventional scatter (funnel) plot of precision versus effect with a folded normal quantile (Z-score) versus effect plot. LFK index values outside the interval between −1 and +1 are deemed consistent with asymmetry (i.e., publication bias). High heterogeneity in the summary effect was further explored using sensitivity analysis. A *p*-value of less than 0.05 was considered as significant.

Evidence Certainty

The certainty of evidence for the systematic review was assessed by two independent reviewers (ADG, MM) using the GRADEpro GDT: GRADEpro Guideline Development Tool (Software), McMaster University and Evidence Prime, 2021, available from gradepro.org. In case of any discrepancy, a consensus was formed by mutual discussion with other reviewers (SSC, RKS, SA, SK).

Risk of Bias

Examination of the methodological quality of the selected studies was performed by two independent reviewers (ADG, MM) using the Joanna Briggs tool. The Joanna Briggs Institute (JBI) 2017 critical appraisal checklist for case–control studies has following questions: (1) were the groups comparable; (2) were cases and controls matched appropriately; (3) were the same criteria used for the identification of cases and controls; (4) was exposure measured in a standard, valid, and reliable way; (5) was exposure measured in the same way for cases and controls; (6) were confounding factors identified; (7) were strategies to deal with confounding factors stated; (8) were outcomes assessed in a standard, valid, and reliable way; (9) was the exposure period of interest long enough to be meaningful; (10) was appropriate strategical analysis used. The risk of bias and concerns about applicability for each question was answered as "yes," "no," "unclear," and "not applicable." Any disagreement in ascertaining JBI tool was solved by consensus.

Results

Summary of Study and Patient Demography

The electronic database search produced 3,928 results. After title and abstract review, 76 citations were identified (►**Fig. 1**), which were considered for full-text review. Sixteen articles met our inclusion/exclusion criteria. The other 60 studies were either case reports, or donor finger outcomes were either not measured or assessed unobjectively. Out of total 368 number

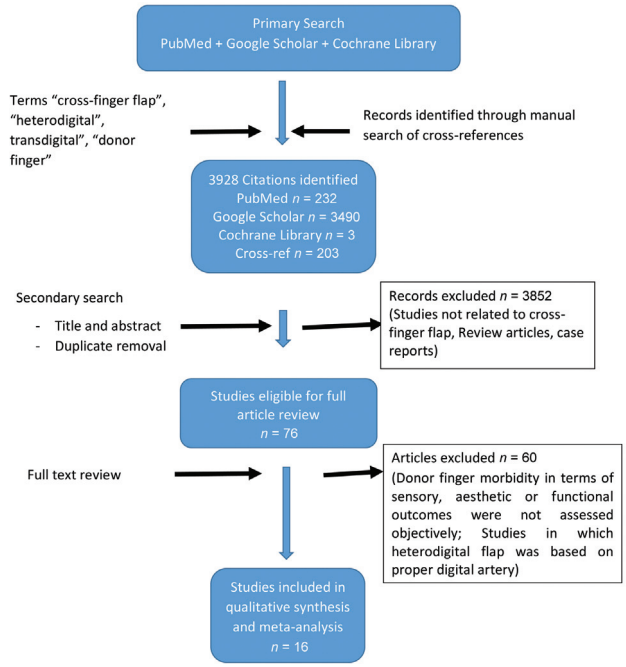

Fig. 1 Flowchart of literature search.

of patients from all included studies, 279 were evaluated objectively against various parameters, pertaining to donor finger morbidity (►**Table 1**). These, 188 males and 48 females, (weighted mean age: 34.3 years) were followed up for a mean 27.7 months. Middle finger was the most commonly used donor finger (index finger= 18.35%, middle finger= 49.37%, ring finger= 29.75%, and little finger= 2.53%).

Summary of Donor Site Morbidity

Six studies had objectively measured the sensory recovery in donor fingers using 2-PD (static two-point discrimination) and/or SW monofilament threshold test (Semmes-Weinstein test) (►**Supplementary Table S2**, online only).[9–14] Five studies have reported sensitivity in control finger.[2,5,9–11] The weighted mean 2-PD of 138 donor fingers is 8.84 mm in comparison to 4.89 mm of contralateral (control) fingers. Although it seems that 2-PD is adversely affected in donor finger, we refrained from performing a meta-analysis for this domain due to lack of adequate data in these studies and high risk of bias. Thirteen studies had measured functional recovery in terms of ROM at IP joints in 204 donor fingers (►**Supplementary Table S3**, online only).[3,8–19] Five studies had reported significant impairment in total ROM at IP joints (p-value < 0.05).[8–10,12,15] The weighted mean total ROM at IP joints of donor and contralateral fingers are 168.6 and 180.1 degrees, respectively. However, there is no statistically significant difference in the ROM between donor and control finger groups (pooled WMD: −12.10; 95% confidence interval [CI]: −28.59, 4.39; $p = 0.00$; $I^2 = 81\%$, $n = 6$ studies) (►**Supplementary Fig. S1**, online only). Since all the included studies were conducted in population with mix of males and females of various age groups, heterogeneity may seem high. To analyze the impact of individual studies on the pooled estimate, a sensitivity analysis was done. It was found

Table 1 Demographic analysis of included studies

Year of publication	Author	Place of study	Type of study/ level of evidence	No of patients (follow-up/ total)	No of patients (male/ female)	Mean age of patients (range) in years	Duration of follow-up (range) in months	Donor finger	Type of cross finger flap
1963	Sturman and Duran[5]	Columbus	–	20/20	–/–	–	6	–	Standard
1992	Nishikawa and Smith[2]	Northwood	Retrospective	15/54	13/2	44 (14–74)	24 (9–48)	–	Standard
2000	Paterson et al[7]	Stourbridge, UK	–	16/16 (17 flaps)	14/2	41 (6–59)	43.5 (6–64)	IF- 4; MF-10; RF-3	Standard
2005	Koch et al[8]	Austria	Retrospective	23/48	21/2	30.28 (1.5–59)	83 (24–215)	IF-5; MF-7; RF-7; LF-4	Standard
2006	Lee et al[14]	Singapore	–	12/12	–/–	–(21–51)	–(1.5–8)	IF-4; MF-3; RF-5	Heterodigital arterialized
2008	Woon et al[3]	Singapore	–	9/30	8/1	50 (27–72)	29 (34–457 days)	–	Standard
2009	Shao et al[13]	Hebei, China	Therapeutic IV	11/11	8/3	36 (19–48)	27 (25–34)	IF-2; MF-8; RF-1	Double innervated based on dorsal branch of PDA (pedicled)
2011	Zhao et al[17]	Hebei, China	–	9/10	6/3	32.8 (22-45)	–(6–24)	IF-2; MF-6; RF-1	Proximally based
2012	Patil et al[16]	Kerala, India	Retrospective	27/27	23/4	33.6 ± 12.8	13 (4–28)	–	Distally based
2012	Wang et al[10]	Hebei, China	Therapeutic IV	18/18	13/5	22	17 (14–25)	MF-18	Standard CFF+ composite free flap 2nd toe
2013	Feng et al[11]	Jiangsu, China	–	18/18	11/7	34.5 (20–52)	20.5 (12–48)	MF-11; RF-7	Pedicled on dorsal branch of PDA
2014	Chen et al[12]	Beijing, China	–	17/17	13/4	32.9 ± 7.9	23 (20–27)	MF-11; RF-6	Bilaterally innervated
				28/28	22/6	32.3 ± 7.5	22 (19–27)	–	Standard
2015	Erken et al[9]	Turkey	Retrospective/ therapeutic IV	12/16	12/0	33.4 (19–58)	28 (19-43)	IF-12	Volar
2015	Chen et al[18]	Beijing, China	Retrospective/ therapeutic IV	22/22	17/5	33 (21–56)	22 (20–24)	–	Innervated pedicled on dorsal branch of PDA
2018	Kim et al[19]	South Korea	Retrospective	11/11	7/4	41	53 (41–63)	MF-4; RF-7	Reverse digital artery
2020	Chitta et al[15]	Kerala, India	Prospective	10/10	–/–	31.5	1	RF-10	Reverse-6 Classical-3 Proximal based-1
Weighted mean				279/368	188/48	34.3	27.7		

Abbreviations: CFF, cross finger flap; IF, index finger; LF, little finger; MF, middle finger; PDA, proper digital artery; RF, ring finger.

that when the study done by Chitta et al[15] was omitted from pooled analysis, the result became homogenous. The pooled WMD was significantly different on exclusion of study by Chitta et al[15] (pooled WMD: −3.38; 95% CI: −10.188, 3.428; $p = 0.746$; $I^2 = 0\%$, $n = 5$ studies; ►**Supplementary Table S4**, online only). Out of 130 patients, 41 (31.54%) had cold intolerance in the donor fingers (►**Supplementary Table S5**, online only). Hyperpigmentation was present in 14 (53.85%) and hypopigmentation in 2 (7.7%) out of 26 donor fingers. Contour deformity was present in 8 (47%) out of 17 donor fingers. Eleven patients (10%) out of 110 reported pain in their donor fingers at follow-up.

Publication Bias

There appears to be no publication bias and small study effects that may be affecting the results of meta-analysis for ROM of IP joints as seen by the Doi Plot with LFK= −0.82 (►**Supplementary Fig. S2**, online only) and funnel plot (►**Supplementary Fig. S3**, online only).

Evidence Certainty

The certainty of evidence assessed for the various outcomes as per GRADE (Grading of Recommendations, Assessment, Development and Evaluations) criteria is of low certainty moderate category (►**Table 2**)

Risk of Bias

Majority of the studies (14 out of 16) failed to state the strategies to deal with confounding factors if any. About one-third studies (6 out of 16) were unclear in stating about the comparability of the groups, matching of cases and controls, and criteria for identification of cases (donor finger) and controls (contralateral finger). Overall, there appears to be a high risk of bias in the included studies (►**Supplementary Fig. S4**, online only).

Discussion

Cross-finger flap and its variants had been undoubtedly the most explored flap for various finger defect reconstructions, owing to its ease of procedure, reliability, safety, satisfactory sensory, functional and aesthetic outcomes, need for only local anesthesia and easily modifiable. Over the period of 70 years, a number of studies had objectively evaluated the outcomes of cross-finger flap reconstruction; however, very little emphasis had been given to evaluate the donor finger morbidity. Few authors[2–6] had reported none to minimal morbidities in the donor finger, although they had not mentioned any objective parameters to measure the same. Extensive literature search revealed only 16 studies recording donor finger morbidity objectively, in cross-finger flaps or its variants. Among them two studies were dedicated on the donor finger morbidity.[7,8]

Many were retrospective studies ($n = 6$), and had level IV evidence ($n = 4$). Apart from standard dorsal cross-finger flap, proximally/distally based, volar, innervated, pedicled on dorsal branch of proper digital artery and reverse digital artery cross-finger flaps have been used. Middle finger has been the most commonly used donor finger. Erken et al reported significant impairment of 2-PD in donor finger ($p = 0.0433$) and of SW monofilament threshold test ($p = 0.0002$).[9] Wang et al also reported statistically significant difference in 2-PD between donor and control fingers ($p = 0.0001$).[10] Feng et al also reported impairment in 2-PD of donor finger (mean = 9.8 mm) in comparison to contralateral finger (mean = 4 mm).[11] The weighted mean 2-PD of 138 donor fingers (8.84 mm) in these included studies suggests impairment in their sensory recovery. However, statistical significance of this impairment could not be assessed due to lack of adequate data in these studies and high risk of bias. More studies will be required to conclusively report regarding impairment in sensation.

The most notable concern in donor finger morbidity is the stiffness in finger joints due to immobilization. Koch et al,[8] Erken et al,[9] Chen et al,[12] and Chitta et al[15] reported statistically significant impairment of the ROM of donor fingers (p-values were 0.03, 0.0005, 0.0001, 0.00012, respectively). While other authors like Woon et al,[3] Shao et al,[13] Patil and Chavre,[16] Feng et al,[11] Zhao et al,[17] and Chen et al[18] reported that the difference between ROM of donor and control fingers is not significant. Wang et al[10] calculated that there was significant impairment of ROM at proximal IP joint, but not at the level of distal IP joint. The difference of weighted mean ROM at IP joint between donor and contralateral fingers suggests finger stiffness. However, our analysis using forest plot, conclusively, proves that there is no statistically significant impairment in ROM of the donor fingers at the IP joints.

Cold intolerance was reported in nearly one-third of donor fingers, which is similar to incidence of cold intolerance in an injured finger. Chen et al[12] reported moderate pain in donor fingers in 20% patients. Chitta et al[15] also found significant difference in aesthetics and pain between donor and control fingers. Forty-seven percent patients reported contour deformity and 53.8% had hyperpigmentation, which does not appear to be satisfactory. We refrained from meta-analysis of the aesthetic outcomes and pain, due to lack of adequate data.

In their long-term follow-up (mean duration 19.7 years), Rabarin et al[4] reported no donor site morbidity, other than cold intolerance. Al-Qattan[20] in a comparative study reported that time of return back to work decreases significantly in cases of immediate postoperative mobilization following cross-finger flap with no increase in risk of complications.

Despite our sincere efforts, there were certain limitations in this study. The heterogeneity of outcomes due to variations in the follow-up period of different studies could not be eliminated. While calculating weighted mean of the various parameters (2-PD, ROM, cold intolerance), the variations in the follow-up period of each type of flap, done by different authors, were not taken into account. Studies have used different parameters and scales to assess sensory, functional, cosmetic recovery, pain, and other donor site morbidities. Hence, statistical significance of all the parameters could not be calculated, either due to lack or incongruity in the data. Long-term morbidity of the donor finger had not been

Table 2 Certainty of evidence using GRADEpro GDT

Certainty assessment							Summary of findings				
Participants (studies) follow-up	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence	Study event rates (%)		Relative effect (95% CI)	Anticipated absolute effects	
							With control	With donor finger		Risk with control	Risk difference with donor finger
Functional outcome (assessed with: range of motion)											
298 (11 observational studies)[a]	Not serious	Not serious[b]	Not serious	Serious[c]	All plausible residual confounding would reduce the demonstrated effect	⨁⨁◯◯ Low	–/149	–/149[a]	Not estimable	Low 0 per 1,000	
Sensory outcome (fine touch sensation) (assessed with: static two-point discrimination)											
96 (3 observational studies)[a]	Not serious	Serious[d]	Not serious	Not serious	All plausible residual confounding would reduce the demonstrated effect	⨁⨁◯◯ Low	–/48	–/48[a]	Not estimable	Low 0 per 1,000	
Sensory outcome (pressure sensation) (assessed with: Semmes-Weinstein monofilament test)											
24 (1 observational study)[a]	Not serious	Not serious	Not serious	Not serious	All plausible residual confounding would reduce the demonstrated effect	⨁⨁⨁◯ Moderate	–/12	–/12[a]	Not estimable	Low 0 per 1,000	
Cold intolerance (follow-up: mean 27.7 months)											
130 (6 observational studies)	Not serious	Not serious	Not serious	Not serious	None	⨁⨁◯◯ Low		41/130 (31.5%)	Not estimable	0 per 1,000	
Aesthetic outcome (follow-up: mean 27.7 months; assessed with: Hyperpigmentation, hypopigmentation, scar instability)											
49 (3 observational studies)	Not serious		Not serious	Not serious		–		20/49 (40.8%)	Not estimable	0 per 1,000	

Abbreviations: CI, confidence interval; GRADEpro GDT, Grading of Recommendations, Assessment, Development and Evaluations pro Guideline Development Tool.

[a]Absence of individual data of all the studies.

[b]Four studies reported statistically significant difference in range of motion of donor and control fingers. Four other studies reported that the difference is not significant statistically. Rest three studies have not reported their *p*-values.

[c]Three studies reported a wide CI.

[d]Two studies reported significant difference between two-point discrimination of donor and control fingers. One study reported no such difference.

assessed by any of the studies. Lastly, confounding factors such as age, gender, nutrition of patients, dimension, and extent of the flap could not be taken into account due to absence of individual data.

Conclusively, it can be said that there is no significant effect on the mobility of donor fingers of cross-finger flap in the follow-up duration. However, the impairment that seems to be in sensory recovery and aesthetic outcomes needs to be further evaluated objectively.

Statement of Human and Animal Rights

This article does not contain any studies with human participants or animals performed by any of the authors.

Level of Evidence

Level of evidence is III.

Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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