OPEN

PRS GLOBAL OPEN

ORIGINAL ARTICLE

Hand

Fingertip Injuries Outcome Score

J. Terrence Jose Jerome, MBBS, FRCS(G), DNB, FNB (Hand & Microsurgery)*
Vijay A. Malshikare, FRCS(G), FCPS(Orth), D.Orth†

Background: Fingertip injury reconstruction aims to restore function and appearance. We report our new fingertip injuries outcome score (FIOS) based on finger length, bone consolidation, nail aesthetics, sensation, range of motion, grip strength, and return to work to evaluate the functional outcome of fingertip injuries.

Methods: We analyzed the reliability and validity of the FIOS in 199 fingertip injuries of varying size, shape, and contours involving soft tissues and the bone. Semi-occlusive dressings and various reconstructive procedures were done based on the geometry. The FIOS had 10 items and specific scores.

Results: The mean follow-up of our study was 26.8 months (range, 18–66 months). We classified the results based on the FIOS. A value of 12 or more is considered excellent; 13–18 is good; 19–24 is fair; and greater than 24 is poor. Excellent or good results were achieved in 186 cases. Nine cases had fair results, and four had poor results. We found the FIOS significantly reliable, consistent (Cronbach's alpha 0.796), reproducible, and valid (ANOVA $P < 0.05$).

Conclusions: FIOS is a simple, reliable, and meaningful method to assess the outcome of fingertip injuries. It is clinically relevant and remains a comparison tool for evaluating the efficiencies of treatment. *(Plast Reconstr Surg Glob Open 2022;10:e4386; doi: 10.1097/GOX.0000000000004386; Published online 16 June 2022.)*

INTRODUCTION

There are various scoring systems and outcome questionnaires to assess hand injury outcomes. This outcome method's primary objective is to evaluate the efficacy of any intervention functional abilities, provide invaluable information about the prognosis, and resume daily activities or return to work. Also, it audits the allocation and performance of health services.[1–6] In addition, it assesses physical, mental, and social functions and the cost-effectiveness of various treatment options.[4–6] The Disabilities of the Arm, Shoulder, and Hand questionnaire, the Patient-Rated Wrist Evaluation, Gartland and Werley score, Michigan Hand Outcomes Questionnaire, Mayo Wrist Score, Hand Injury Severity Score, Patient-Reported Outcomes Measurement Information System, and Short Form 36 are commonly used patient-reported outcome measures.[2–11] These patient-reported outcome measures provide insight into the patients' quality of life, upper extremity function, and pain. Also, they have questionnaires designed to assess the impact of the treatment from the patient's perspective. However, none of these scores appropriately evaluated fingertip injuries.

Therefore, there is still a need for specific fingertip injuries outcome scores that should be simple, reliable, internally consistent, and suitable for all hand trauma populations. Therefore, we proposed a fingertip injuries outcome score (FIOS) based on objective and patient-based subjective measurements. The FIOS assessed the postoperative finger length, bone consolidation, nail aesthetics and cosmetics, sensation, range of motion, grip strength, and return to work in fingertip injuries. As a result, we hypothesize that the FIOS is a simple, reliable, valid, and meaningful outcome score for fingertip injuries.

METHODS

Patients and Ethics

We prospectively analyzed 200 patients with Allen type 1–4 fingertip amputations[12] between 2015 and 2019, where one patient was lost to follow-up for an unknown reason. An ethical committee board approved the study. The mean age of the 199 patients in the study was 31

*From the *Department of Orthopedics, Hand, and Reconstructive Microsurgery, Olympia Hospital & Research Centre, Trichy, Tamilnadu, India; and †Jehangir and 18.52 North Hospital, Pune, India.*

Received for publication March 7, 2022; accepted May 4, 2022.

DOI: 10.1097/GOX.0000000000004386

Disclosure: *The authors have no financial interest to declare in relation to the content of this article.*

Related Digital Media are available in the full-text version of the article on www.PRSGlobalOpen.com.

Table 1. Fingertip Injuries Outcome Assessment Score

		Score
Nail	Normal	1
	Small nail	2
	Split nail or deformed nail	3
	Hook nail	4
	Absent nail	5
Finger length (length compared with normal side length from volar crease to fingertip)	Distal third	1
	Middle third	2
	Proximal third	3
Pulp	Well padded	1
	Pulp atrophy	2
Bone	Fracture united (consolidated) or normal	1
	Nonunion	2
	Bone shortening	3
Cosmesis	Satisfactory	1
	Not satisfactory (color mismatch)	2
Sensation (2-PD)	<6 mm	1
	7–10 mm	2
	Cold intolerance	3
	Absent sensation/ hyperalgesia	4
Pain	No pain	1
	Mild	2
	Moderate	3
	Severe	4
Range of motion (TAM)	75%–100%	1
	50%–74%	2
	<49%	3
Grip strength	75%–100%	1
	50%–74%	2
	<49%	3
Return to work	Regular job	1
	Restricted job	2
	Unable to work	3

years (range 1.5–57 years). There were 120 patients with right-side involvement. There were 169 men. Transverse amputation was seen in 94 patients, dorsal oblique in 24 patients, radial oblique in 29 patients, ulnar oblique in 27 patients, and volar oblique in 25 patients. The thumb was involved in 79 patients, the index finger in 55 patients, the middle finger in 25 patients, the ring finger in 20 patients, and the little finger in 20 patients. Most injuries were crush (182 cases) or guillotine type (17 cases), all caused by machine injuries or knives.

Takeaways

Question: What is a specific outcome method or score for fingertip injuries?

Findings: The fingertip injuries outcome score (FIOS) is a simple, reliable, and meaningful method to assess the outcome.

Meaning: The FIOS is a reproducible, consistent, and valid score for all fingertip injuries.

SURGICAL TECHNIQUE

The authors have more than 12 years of experience in hand surgery and performed all the surgeries. Allen's type 1 and 2 amputations were managed with semiocclusive dressing (allowed healing by secondary intention), palmary V-Y plasty, lateral V-Y plasty, Moberg flap, and Venkataswami (Oblique) flap. Allen's type 3 amputation was treated by nail bed graft, graft reposition flap (cross finger flap/ thenar flap), homodigital, and first dorsal metacarpal artery flap. Allen's type 4 had graft reposition flap and replantation.

Fingertip Injuries Outcome Score

The results of 199 patients were classified based on nail aesthetics, finger length, pulp pad, bone consolidation,

Fig. 1. Nail involvement and the corresponding scores.

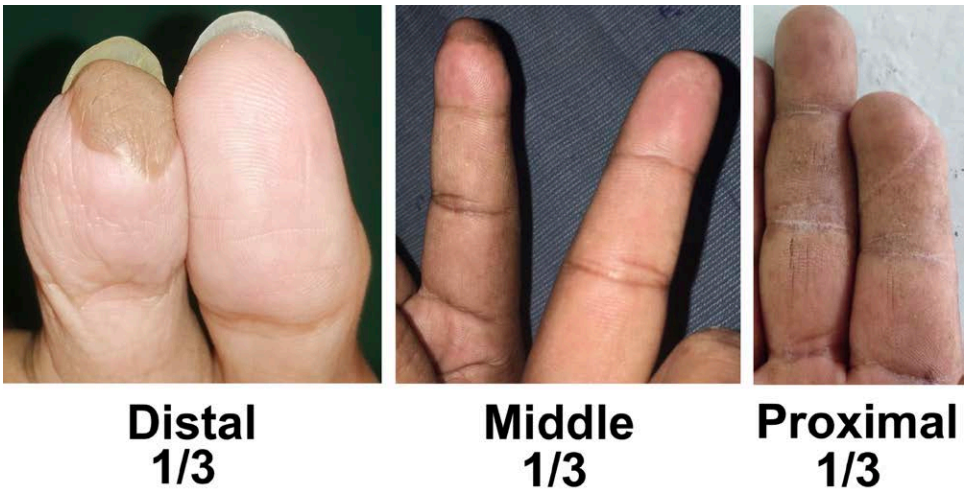

Fig. 2. Finger length and the related scores.

cosmesis, sensation, pain, range of motion, grip strength, and return to work (Table 1) (Figs. 1–5). Two independent observers rated the FIOS (a senior hand surgeon and a senior orthopedic surgeon). The two examiners underwent a 30-minute training session to become familiar with the FIOS and how to properly mark the score for each patient involved in the study.

Statistical Analysis

The reliability and internal consistency of the FIOS were assessed using Cronbach's alpha test. In addition, we used ANOVA to determine the validity of the fingertip assessment score by comparing the mean value of all patients in different types of amputation. An alpha value of 0.70> α ≥0.60 was considered acceptable, 0.8 > α ≥0.70 was good, and 90> α ≥0.80 was defined as excellent. Similarly, for the ANOVA test, a *P* value less than 0.05 was considered significant. The Cohen Kappa (κ) statistic was used to test interrater reliability.[13]

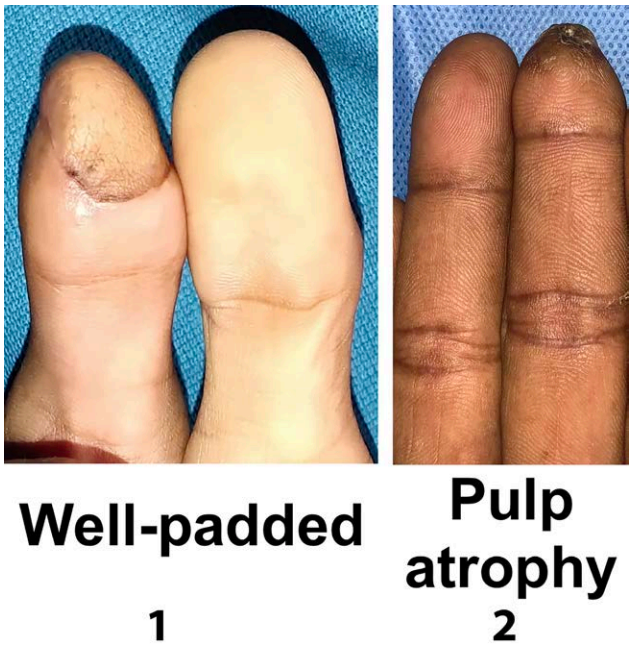

Fig. 3. Pulp quality and the associated scores.

RESULTS

The mean operating time in our study was 38 minutes (range, 25–190 minutes). The mean follow-up of our study was 26.8 months (range,18–66 months). Our study had 50 Allen's type I, 51 Allen's type II, 49 Allen's type III, and 49 Allen's type IV injuries. We performed cross finger flaps (n = 55), Oblique triangular flaps (n = 55), Volar V-Y advancement flap (n = 42), antegrade homodigital flap (n = 12), Thenar flap (n = 6), Moberg flap (n = 3), replantation (n = 4), and first dorsal metacarpal artery flap (n = 1) in our series. We had treated 21 patients with semiocclusive dressings. The results were classified based on the FIOS (Figs. 6, 7). A value of 12 or more was considered excellent; 13–18 was good; 19–24 was fair; and greater than 24 was poor (Table 2). Excellent (n = 127) or good (n = 59) results were achieved in our study. The internal consistency and reliability of the FIOS assessed by Cronbach's alpha were 0.796, in the acceptable range. (**See table, Supplemental Digital Content 1,** which displays the Cronbach's alpha results. **http://links.lww.com/PRSGO/C59**.) The overall Cronbach's alpha value was greater than the other coefficients (0.771, 0.759, 0.793, 0.789, 0.768, 0.791, 0.785, 0.754, 0.788, 0.782) obtained from the 10 different items. (**See table, Supplemental Digital Content 2**, which displays the Cronbach's alpha coefficients and item deletion details. **http://links.lww.com/PRSGO/C59**.) The validity of the FIOS assessed by the ANOVA was found significant ($P < 0.0001$). (**See table, Supplemental Digital Content 3,** which displays the ANOVA results. **http://links.lww.com/PRSGO/C59**). The interrater reliability Cohen Kappa (κ) value was 0.844, which confirmed a strong agreement between the rater over various items in the score. (**See table, Supplemental Digital Content 4,** which displays reliability analysis: interpretation of Cohen's Kappa. **http://links.lww.com/PRSGO/C59**.)

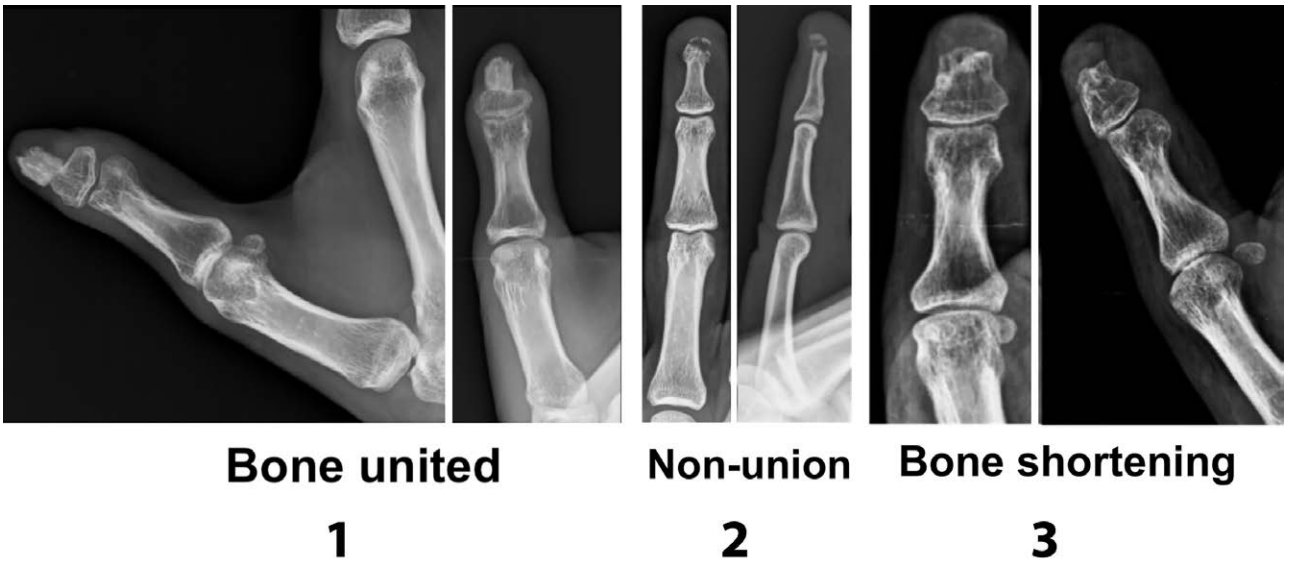

Fig. 4. Bone consolidation and the associated scores.

DISCUSSION

Fingertip injury outcome assessment should focus on both objective and patient-based subjective measurements. Objective measurements must be easy to select and include factors that are expected to change after treatment. The objective and subjective measures include finger length, nail and pulp aesthetics, pulp contour, sensation, pain, range of motion, bone union, grip strength, and return to work.[14,15]

Fig. 5. Fingertip cosmesis and the associated scores.

Our study had 199 patients with 10 Likert-type items. Each item had different values with a score. For example, the nail had five items with a score of 1–5; sensation and pain had items with a score of 1–4; finger length, bone consolidation, range of motion, grip strength, and return to work had a score of 1–3; pulp and cosmesis had items with scores of 1 and 2. Cronbach's alpha is a statistic commonly quoted by authors to demonstrate that tests and scales/scores construed or adopted for research projects fit the purpose.[16,17] Taber KS has documented that a Cronbach's alpha reliability coefficient (α) greater than or equal to 0.70 is acceptable in most science research situations.[16] Our study had 0.796, which is good and acceptable reliability. Furthermore, this alpha value indicated that the FIOS gave the same outcome when measurements were repeated. Therefore, the FIOS is reliable and has internal consistency because of repeated measures (test-retest reliability).

The authors have designed the score based on their experience with fingertip injuries.[18] With careful statistical analysis using the Cronbach addition/deletion of Likert items, the score was narrowed to 10 items. The Cronbach alpha (α) indicates interrater reliability, internal reliability, unidimensionality, and coherence.[16,17] In our study, the acceptable alpha ($\alpha = 0.796$) confirmed interrater reliability, internal reliability, unidimensionality, and coherence. This high alpha value implied that every item in the FIOS measured the same thing or something similar to some of the other items. Also, these 10 items correlated well with some other items (inter-relatedness) and demonstrated internal consistency. The FIOS measured what it claimed to measure and was unidimensional with valid items. The FIOS also had questions that measured one construct dimension and proved it fundamental. Also, the ANOVA test assessed the means of type 1–4

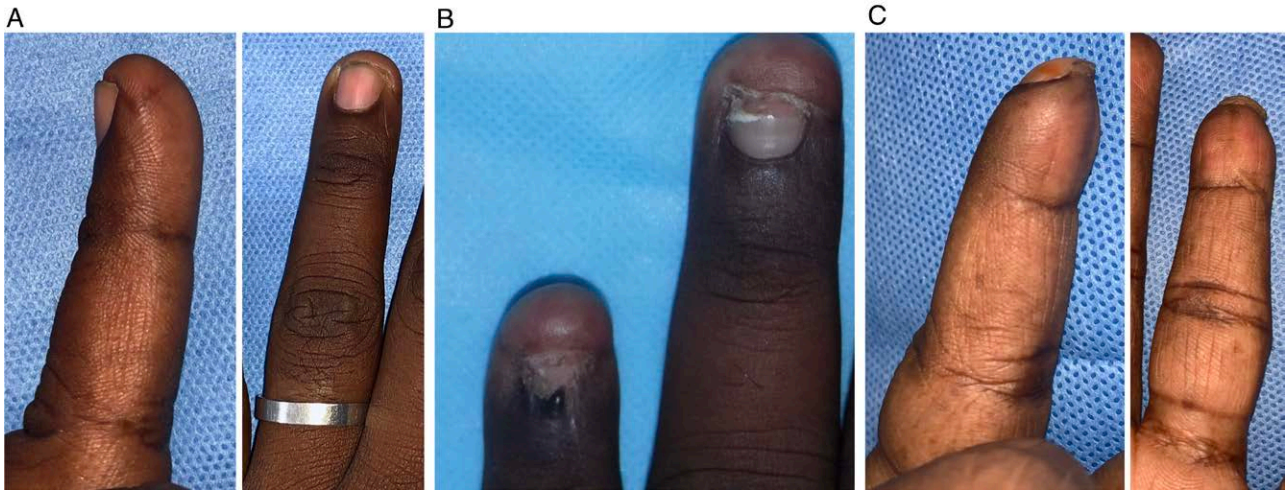

Fig. 6. Pictures of patients with various FIOS. A, FIOS of 11 (excellent) in a V-Y advancement flap and nailbed repair following a crush injury. B, FIOS of 18 (good) with split and deformed nail following a door crush injury. C, FIOS of 24 (fair) with hooked nail deformity in Allen's type III amputation.

amputations and correlated with the FIOS. Therefore, the FIOS was valid and found to be statistically significant ($P < 0.00001$).

The overall strength of the study remained in item creation (10 Likert-type items) specific for fingertip injuries outcome score. The objective assessments included nail, finger length, pulp, bone, sensation, range of motion, and grip strength; the subjective assessments included pain, cosmesis, and return to work. In addition, we have analyzed and avoided items of high difficulty; items that are only loosely related to each other; items that are problematic, irrelevant, and nonspecific. This made the score easy to use at various levels, such as a senior orthopedics consultant and senior colleagues in hand surgery. Cohen suggested a Kappa (κ) value of 0.80–0.90 has 64%–81% reliability of the data.[12] Our study noted an κ value of 0.844 that confirmed a strong agreement between the raters. This could lead to recommendations for changing practice to follow the FIOS based on the strong agreement in healthcare research. Adding more items to the FIOS can increase the alpha value, but these additional items may cause redundancy if the added items measure the same thing.

Fig. 7. FIOS of 28 (poor) in an amputation of the fingertip in a crush avulsion injury.

After checking the reliability of each factor using the Cronbach α coefficient, items that decreased the reliability of each factor can be removed. Supplemental Table 3 showed Cronbach's alpha if an item deleted to make the score offers further validation and consistency (http://links.lww.com/PRSGO/C59). However, there was no necessity in the FIOS for item deletion because of the careful item creation and avoidance of redundant items. Thus, the strength and advantage of our study lie in the validation done by Cronbach's alpha and ANOVA test.

The main intention of the study is to recommend the FIOS for use in all fingertip injuries. The score is comprehensive, comparing the preoperative and postoperative functional aspects and return to work. Also, we

Table 2. Results

Results	Score Value	Patients
Excellent	≤12	127
Good	13–18	59
Fair	19–24	9
Poor	>24	4

believe that this score will be simple, straightforward, and quickly assessed during the outpatient/office visit of the patient with their radiographs and outcome pictures. FIOS provides better communication about the treatment, helps in decision-making, and evaluates the patient's satisfaction and improvement following the treatment/care they received. Moreover, the Disabilities of the Arm, Shoulder, and Hand, Patient-Rated Wrist Evaluation, Michigan Hand Outcomes Questionnaire, Patient-Reported Outcomes Measurement Information System, Hand Injury Severity Score, and other patient-reported outcome measures did not appropriately evaluate fingertip injury outcomes.

The bone consolidation score has a limiting factor based on the surgical treatment. For example, fingertip replantations and graft reposition flaps in Allen's type IV amputations had the distal part (amputated distal phalanx) attached with the proximal portion of the distal phalanx in the stump. They reported good union in the study and maintained a near-normal finger length. This was the reason for a good score of 1 in severe injuries of Allen's type IV amputation. Contrarily, Allen's type III amputations had only flap reconstruction without reattaching the amputated distal phalanx, which was the reason for bone length shortening in the study and bone consolidation score of 3. Also, the nonunion of the distal phalanx in Allen's type II injuries was asymptomatic and maintained the bone length to have a score of 2.

The difficulty in testing the reliability of an aptitude test or knowledge test by simply undertaking repeated readings is another limitation of the FIOS. The patients are constantly changing or may change due to experience between 10 Likert-type items in the FIOS. So, a patient may answer a set of subjective questions such as pain, cosmesis, and sensation differently for no other reason than that responding to the original FIOS provided a learning experience. Cronbach suggested that alpha "reports how much the test score depends upon the general and group, rather than item-specific factors."[19] A lot of variances depend on general respondent-related factors (pediatric age, intelligence, study diligence, patient motivation). We offer the readers the 10 items included in the FIOS to judge face equivalence. It is fully open to critique and detailed enough to support further research iteratively.

Nevertheless, the fingertip injuries outcome score (FIOS) is simple to use in most populations, reliable, valid, and a meaningful assessment score method for fingertip injuries.

J. Terrence Jose Jerome, MBBS, FRCS(G), DNB, FNB (Hand & Microsurgery)
Department of Orthopedics, Hand and Reconstructive Microsurgery
Olympia Hospital & Research Centre
47, 47A Puthur High Road
Puthur, Trichy 620017
Tamilnadu, India
E-mail: terrencejose@gmail.com

ACKNOWLEDGMENTS

We sincerely thank Dr. Mike from Mexico, who rendered invaluable statistical support for this study. Ethical approval for this study was obtained from the Ethical Committee Board of Olympia Hospital and Research Centre, approval (No. 03/2021). This clinical trial was not registered but followed ICMJE requirements.

REFERENCES

1. Marks M. Which patient-reported outcomes shall we use in hand surgery? *J Hand Surg Eur Vol.* 2020;45:5–11.
2. Beaton DE, Wright JG, Katz JN; Upper Extremity Collaborative Group. Development of the QuickDASH: comparison of three item-reduction approaches. *J Bone Joint Surg Am.* 2005;87:1038–1046.
3. Brodke DJ, Saltzman CL, Brodke DS. PROMIS for orthopaedic outcomes measurement. *J Am Acad Orthop Surg.* 2016;24:744–749.
4. Fidai MS, Saltzman BM, Meta F, et al. Patient-reported outcomes measurement information system and legacy patient-reported outcome measures in the field of orthopaedics: a systematic review. *Arthroscopy.* 2018;34:605–614.
5. Horng YS, Lin MC, Feng CT, et al. Responsiveness of the Michigan hand outcomes questionnaire and the disabilities of the arm, shoulder, and hand questionnaire in patients with hand injury. *J Hand Surg Am.* 2010;35:430–436.
6. MacDermid JC. The PRWE/PRWHE update. *J Hand Ther.* 2019;32:292–294.
7. McMillan CR, Binhammer PA. Which outcome measure is the best? Evaluating responsiveness of the disabilities of the arm, shoulder, and hand questionnaire, the Michigan hand questionnaire and the patient-specific functional scale following hand and wrist surgery. *Hand (N Y).* 2009;4:311–318.
8. Dacombe PJ, Amirfeyz R, Davis T. Patient-reported outcome measures for hand and wrist trauma: is there sufficient evidence of reliability, validity, and responsiveness? *Hand (N Y).* 2016;11:11–21.
9. Heras-Palou C, Burke FD, Dias JJ, Bindra R. Outcome measurement in hand surgery: report of a consensus conference. *British J Hand Ther.* 2003;8:70–80.
10. Shauver MJ, Chung KC. The Michigan hand outcomes questionnaire after 15 years of field trial. *Plast Reconstr Surg.* 2013;131:779e–787e.
11. Campbell DA, Kay SP. The hand injury severity scoring system. *J Hand Surg Br.* 1996;21:295–298.
12. Allen MJ. Conservative management of finger tip injuries in adults. *Hand.* 1980;12:257–265.
13. McHugh ML. Interrater reliability: the kappa statistic. *Biochem Med (Zagreb).* 2012;22:276–282.
14. Malshikare VA. Graft reposition on flap: Mid-term result in Allen type IV amputation. *J Hand Surg Asian Pac Vol.* 2019;24:219–223.
15. Jerome JTJ. Reconstruction of motorcycle spokes wheel injury fingertip amputations with reposition flap technique: a report of 40 cases. *Eur J Trauma Emerg Surg.* 2022;48:573–584.
16. Taber KS. The use of Cronbach's alpha when developing and reporting research instruments in science education. *Res Sci Educ.* 2018; 48:1273–1296.
17. Wild A. Relationships between high school chemistry students' perceptions of a constructivist learning environment and their STEM career expectations. *Int J Sci Educ.* 2015; 37:2284–2305.
18. Jerome JTJ, Malshikare VA. Graft reposition flap for fingertip injuries. *Orthoplastic Surg.* 2022; 8:17–25.
19. Cronbach LJ. Coefficient alpha and the internal structure of tests. *Psychometrika.* 1951; 16:297–334.