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ORIGINAL ARTICLE

Burns

Recalcitrant Bilateral Volar Hand Burn Contracture in a Toddler Treated With Integra and Staged Full-thickness Skin Graft: A Literature Review

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Background: Recurrent burn contractures on the volar aspect of the hand present a formidable challenge, especially in the pediatric patient. We used Integra followed by staged full-thickness skin grafting for recurrent bilateral volar hand burn contracture in a toddler. We reviewed the literature to appraise the utility of full-thickness skin graft (FTSG) combined with Integra used for volar hand contractures.

Methods: A systematic review of the world's literature was conducted identifying publications on the application of Integra and skin substitutes for palmar hand contractures and wounds, to include burn injuries. We describe a case of a pediatric patient with recurrent bilateral burn flexion contracture of the palm and digits treated with scar excision and application of Integra, followed by staged application of FTSG.

Results: We identified 92 publications pertaining to volar hand defects or contractures managed with skin grafts, skin substitutes, and/or flaps. Ten articles referred to the use of Integra on volar hand wounds or contractures, and only 2 articles used FTSG instead of split-thickness skin graft in combination with Integra. Our systematic review of volar burn injuries of the hand and fingers demonstrated that the use of Integra combined with FTSG for postburn flexion contracture of the hand has not been previously reported.

Conclusions: This case report suggests that application of FTSG instead of split-thickness skin graft to vascularized Integra offers protective value against recurrent burn contracture of the palmar hand, but more studies are needed to support our hypothesis. *(Plast Reconstr Surg Glob Open 2025; 13:e6430; doi: 10.1097/GOX.0000000000006430; Published online 17 January 2025.)*

INTRODUCTION

Deep burn injury to the volar aspect of the hand presents a formidable challenge, especially in the pediatric patient. The difficulty in restoring form and function correlates with the depth and extent of surface area of the burn, particularly those involving both the palm and volar side of the digits. The methods of reconstruction reported in the medical literature for such burn injuries vary among different authors, extent/location of damage, and time periods in the evolution of surgical procedures. More recently, regenerative dermal templates, such as Integra Dermal Regenerative Template (Integra LifeSciences, Princeton, NJ), have found their utility in preparing a less-than-ideal wound bed for skin grafting.[1–3] To a certain extent, bare tendons and bone can be successfully covered by Integra,[4–6] which forms neodermis in 3–4 weeks to allow subsequent application of a split-thickness skin graft (STSG) on top of it. The outcome is a thicker skin graft compared with STSG alone. Full-thickness skin grafting (FTSG) on top of Integra is not common practice because the Integra provides for the formation of neodermis. However, in volar burn recurrent contracture of combined digits and palm, the authors advocate

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for the use of FTSG after Integra resurfacing to provide maximal thickness of skin reconstruction and mitigate against recurrence of flexion contracture. We present a case report of a pediatric patient with recurrent bilateral burn flexion contracture of the palm, fingers, and thumb treated with scar excision and application of Integra, followed by staged FTSG. We conducted a systematic review to determine how many articles have described the use of FTSG following Integra application for volar hand skin defects or contractures.

Takeaways

Question: Will a staged full-thickness skin graft (FTSG) placed on top of Integra provide good take and coverage in recurrent volar hand contracture?

Findings: The combination of Integra and staged FTSG took well and provided satisfactory skin coverage without recurrent recalcitrant flexion contracture. Systematic review found only 2 articles describing the use of staged FTSG applied over Integra for volar hand skin defects.

Meaning: Placing FTSG on top of Integra has been reported scarcely but may offer some benefit by increasing the thickness of the reconstructed skin when needed.

METHODS

Case Report

We describe a case of a 19-month-old boy who fell onto burning pine needles 1 day previously with second- and third-degree burns sustained to bilateral forearms and hands of 4.5% total body surface area, which included both palms and all digits on their volar aspects. On December 10, 2020, he was transferred from an outside hospital to the pediatric burn unit. The patient received conservative wound management with enzymatic debridement until 11 days after admission, at which time excisional debridement and STSG were performed. Both small fingertips were burned to the distal phalanx, and the right small fingertip was not salvageable. He was discharged on postoperative day 5 with outpatient hand therapy and use of compression garments. He required readmission and repeat STSG after hypertrophic granulation debridement 38 days postinjury. He developed severe bilateral hand flexion contractures involving all the digits and the palm. He then underwent excision of contractures with placement of Integra and Kirschner pins across left ring and small and right long, ring, and small fingers crossing all 3 joints for 6 weeks. STSG was performed 3 weeks after Integra placement. However, he presented 2 months later with recurrent flexion contracture in both hands despite take of STSG (Fig. 1). The senior author had not performed these prior skin grafts.

Fig. 1. Preoperative photographs of the left and right hands in severe recurrent contracture only 2 ½ months (A) and 3 months and 3 weeks (B) after STSG over Integra, respectively.

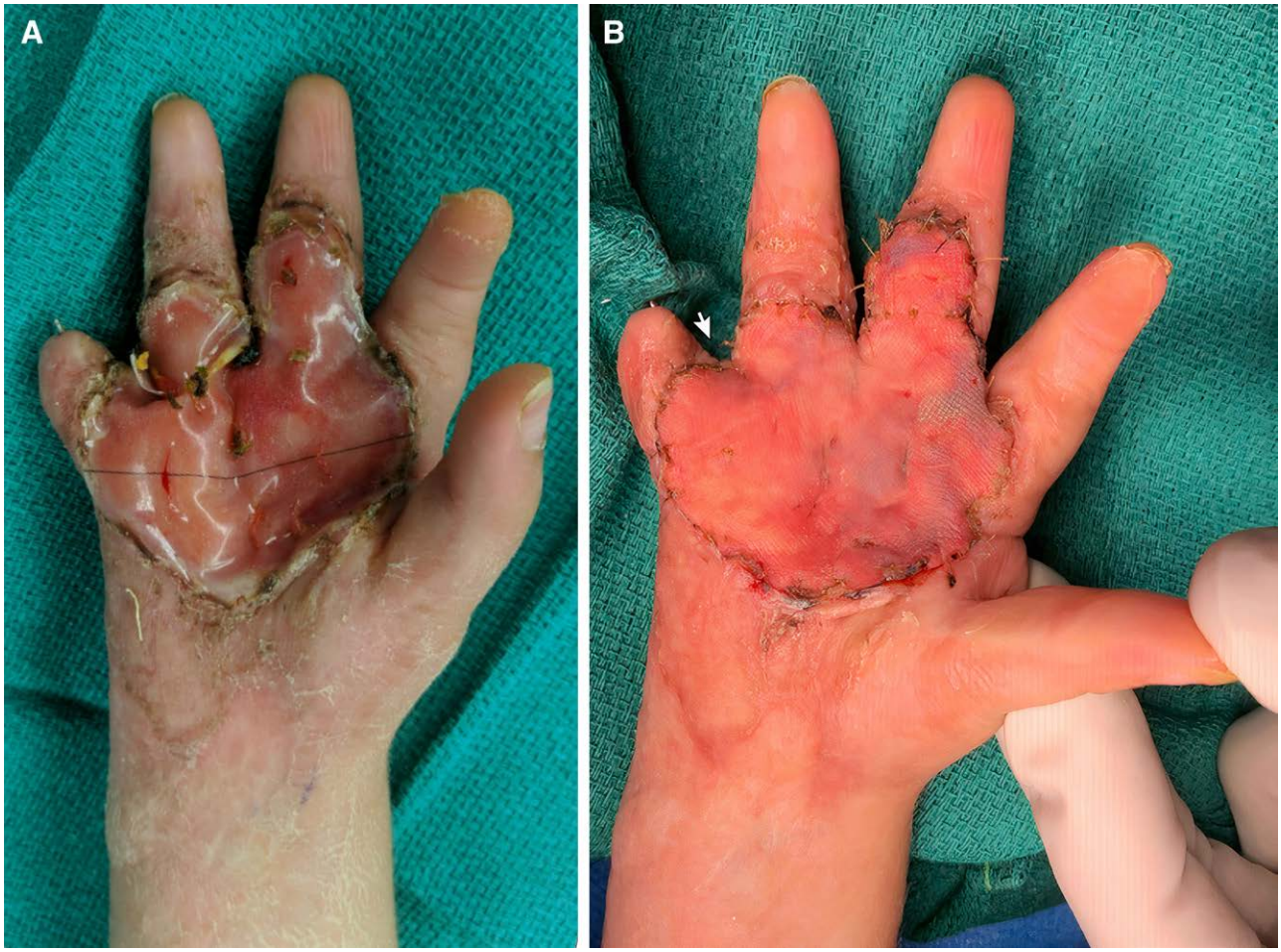

Fig. 2. Early postoperative views after first and second-stage surgery to the right hand. A, Right hand 23 days after recurrent contracture excision and application of Integra. B, Seven days after FTSG on top of neodermis formed by Integra.

The child's recurrent flexion contracture care was then turned over to the senior author, whose procedures spanned from mid-September to mid-November of 2021. His previous Integra and staged STSGs took well, but contracture rapidly recurred despite hand therapy and postoperative splinting. Therefore, the surgical management had to be modified. Distant flap surgery was not considered due to his young age; attaching his hands temporarily to his trunk and submitting him to a long hospital stay were not favored by his parent. In addition to Integra, a plan to use FTSG and a much longer duration of pin fixation was devised by the senior author.

Repeat flexion contracture release began with the patient's right hand. Once the flexion contracture scars were excised, percutaneous skeletal fixation with 0.028″ Kirschner wires was performed to his right long and small fingers, traversing across all joints, including the metacarpophalangeal joint. The pins were placed with ends cut off deep to the skin to minimize infection due to their long duration of fixation. The bilayer unmeshed Integra graft was applied to the palmar hand defect and to each of the digits. The grafting included the second, third, and fourth web spaces. Previous skin graft on the thenar eminence and wrist were retained. The Integra was sutured with bolster dressings, and then a long-arm club cast was applied. The patient was sent home the same day, and then returned on postoperative day 9 for a dressing change in the operating room (OR) (Fig. 2A). Twenty-three days after Integra placement, FTSG was performed with the right groin as the donor site. Because of the patient's young age, his groin donor site allowed a large piece of FTSG to be harvested and yet allowed primary closure. A single piece of the FTSG was used for the entire defect, including the ring and small fingers, except for a small portion of the long finger that was grafted with a separate segment (Fig. 2B). The skin graft was sutured down on the volar aspect to the depth of the interdigital crease between long and ring fingers, ring, and small fingers, and to the palmar defect. The pin to the right ring finger spontaneously backed out completely after 1 week, but the finger remained in near straight position secondary to a quadriga phenomenon with both small and long fingers pinned in the straight position. Immobilization was achieved in the same manner as stated previously. The duration of pin fixation to the right long finger was 9 weeks and 2 days. The small finger pin spontaneously extruded shortly after. The ring finger pin inadvertently came out at 3 weeks and 2 days and was replaced 2 weeks later during a return trip to the OR; this pin stayed in for another 5 weeks.

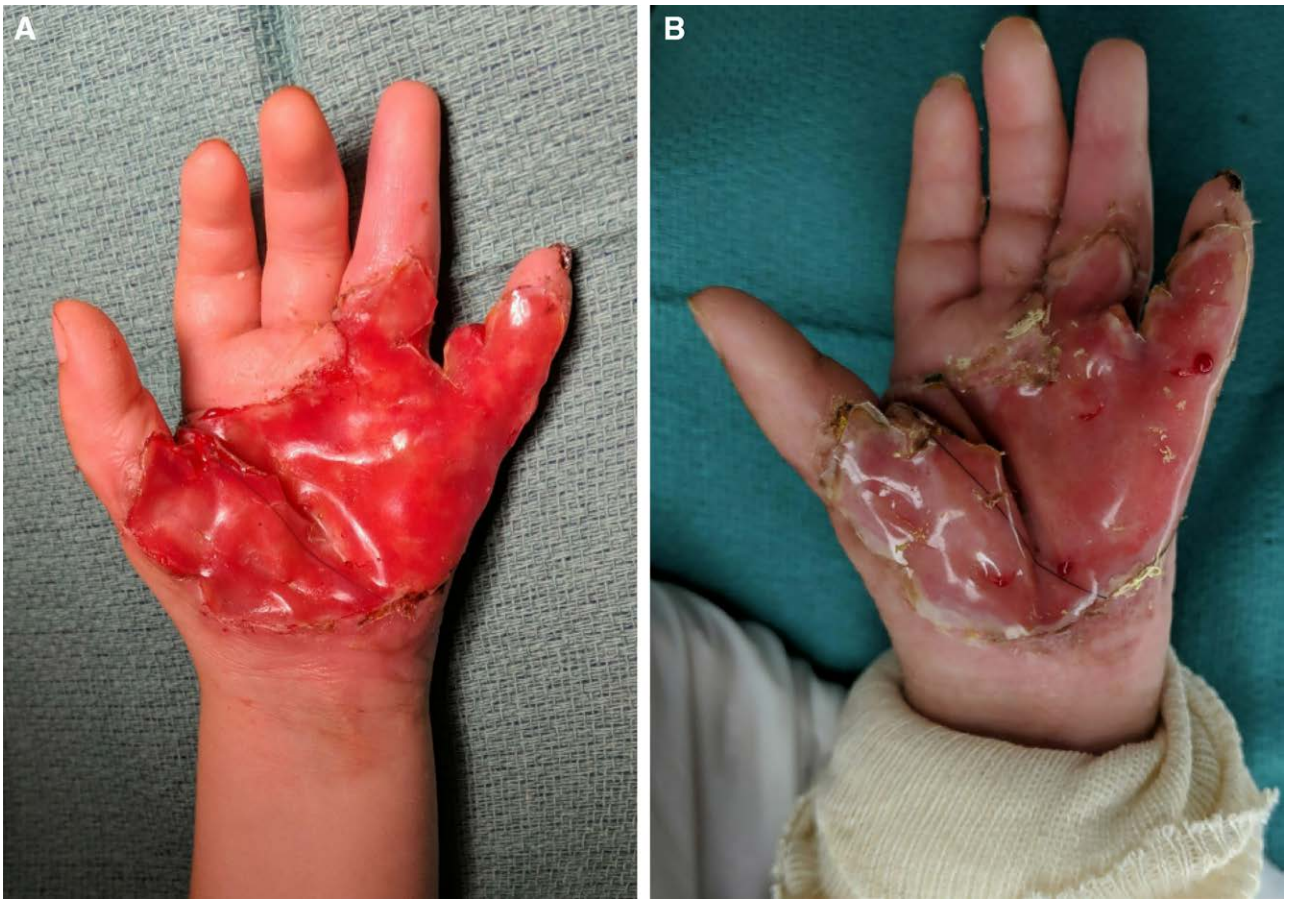

Fig. 3. Post-operative views of the left hand showing Integra integration. A, Left hand at 8 days. B, Twenty-four days after recurrent contracture excision with application of Integra.

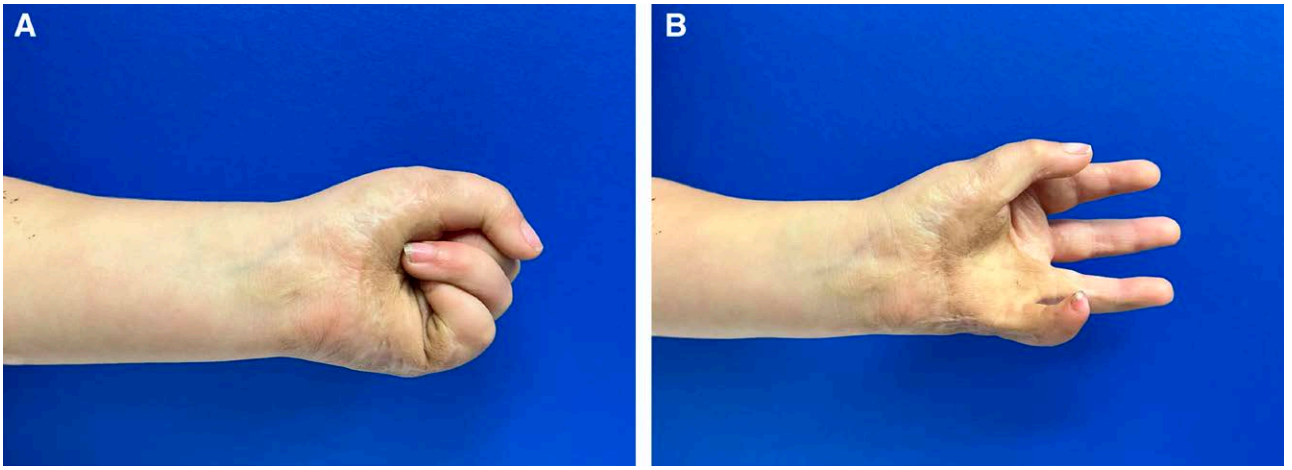

Fig. 4. Postoperative views after completion of two-stage reconstruction to the left hand. Postoperative closed-fist (A) and volar views (B) of his left hand at approximately 18 months. Note persistent flexion contracture of his left small finger.

After 6 weeks from the first surgery to his right hand, the patient returned to the OR to begin the same series of procedures to the left hand. The K-wires were used in the left ring and small fingers because the contracture to the long finger was not severe. A single piece of Integra was used for the entire defect, except for several small pieces placed within the first and fourth web spaces. A bolster dressing and long-arm club were applied, which were changed in the OR 8 days later (Fig. 3). An FTSG from the left groin to the volar aspect of the left hand

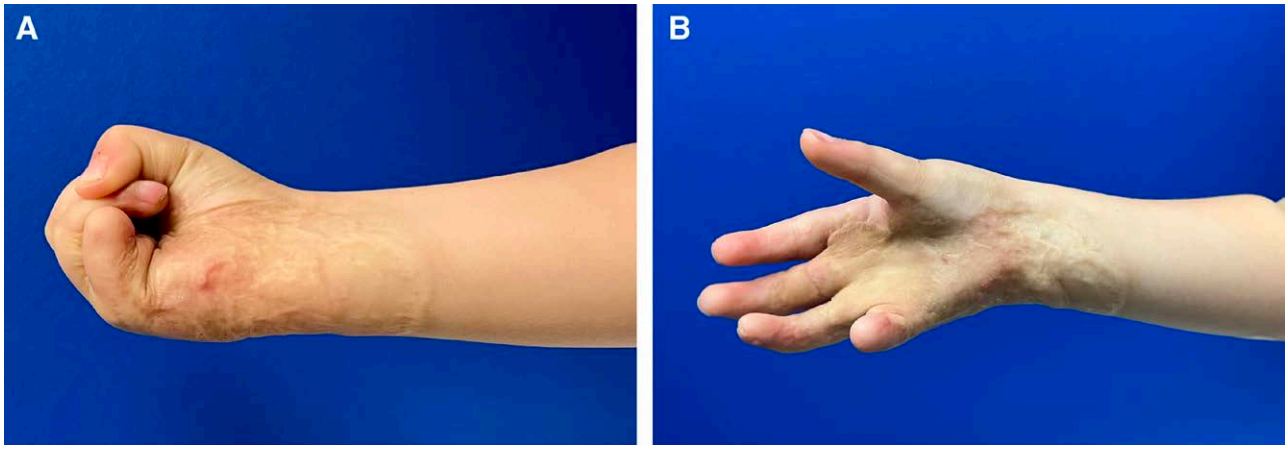

Fig. 5. Postoperative views after completion of two-stage reconstruction of the right hand. A and B, Right hand at postoperative 20 months.

Fig. 6. Postoperative views showing marked improvement in first web contracture bilaterally.

was performed 24 days after Integra placement. A single piece of FTSG was used for the entire defect, except for a small portion of the left ring finger, which received a separate piece of graft. While undergoing physical therapy, the patient contracted COVID-19, thereby delaying pin removal from the left ring and small fingers; duration of pinning was 16 weeks. All surgical pin removal was performed under general anesthesia. He experienced no wound healing complications. Due to practice change of the senior author, the toddler's long-term follow-up was transferred to the orthopedic hand service. Hand therapy continued for 1 year from the last skin graft.

The patient's residual right small finger distal phalanx produced aberrant nail, and the distal interphalangeal joint remained contracted. This distal finger underwent amputation at the proximal interphalangeal joint along with first web Z-plasty at 17 months postoperatively by the orthopedic hand service. He was last seen by the senior author at 1 ½ years postoperatively (Figs. 4–7). His left small finger has persistent metacarpophalangeal joint contracture, but his overall hand function remained good. Seven of the main handgrips, according to Sollerman and Ejeskär[7] (pulp pinch, lateral inch, tripod pinch, 5-digit pinch, diagonal, transverse, and spherical volar grip), in both hands were normal or near normal. His hand function remained stable at 2 years postoperatively.

Systematic Literature Search

The results of this systematic review were reported in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) reporting guidelines. The medical librarian compiled terminology

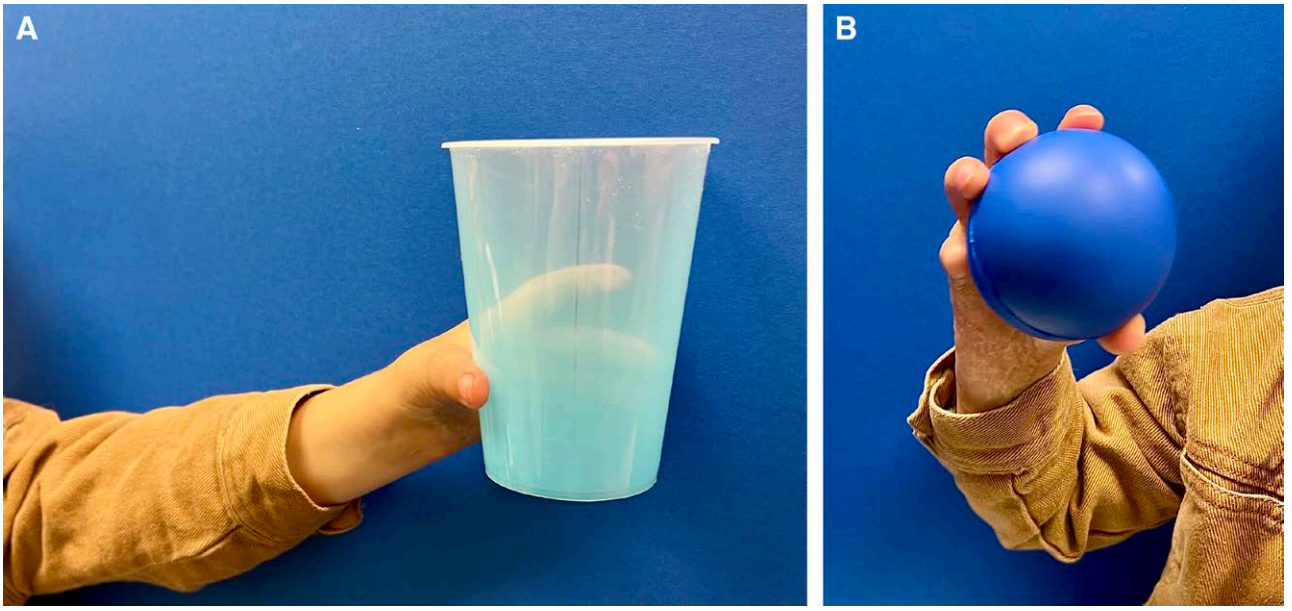

Fig. 7. Hand use demonstration. Left- (A) and right-hand (B) grasp demonstrated.

and identified Medical Subject Headings and synonyms for all concepts. Advanced searching techniques used included nesting, adjacency searching and truncation. The initial build was in MEDLINE and strategy syntax was translated as appropriate to the specific database and platform. (**See appendix, Supplemental Digital Content 1**, which displays MEDLINE search strategy. All languages are included to procure a comprehensive study on volar/palmar wound and contracture surgical treatments. Full search strategies for all databases are available upon request, **http://links.lww.com/PRSGO/D769**.) All languages were included, and all years within each database were searched.

The PRISMA guidelines were followed during this systematic review to identify and select studies from the PubMed, OVID, EMBASE, and Cochrane (C) collection, EBSCO, and Web of Science databases. Grey literature and international resources, such as the World Health Organization's Global Index Medicus and International Clinical Trials Registry, Clinical Trials.gov, the National Institute for Health, and Care Excellence were searched. These databases and vendor platforms were searched from their beginning date of collection to August of 2022. The MEDLINE strategy is provided (**Supplemental Digital Content 1, http://links.lww.com/PRSGO/D769**).

Database results were uploaded to desktop folders within EndNote X9 (Clarivate Analytics, Philadelphia, PA) and results were combined into one for duplicate removal. The unique set was uploaded to Covidence (Veritas Health Innovation, Melbourne, Australia: www.covidence.org), a screening tool for systematic reviews. Study abstracts and full text were screened in Covidence for eligibility independently by two reviewers. Disagreements were resolved through discussion by J.C.Y. and J.L.W.

Inclusion Criteria

This review included published articles describing wound and contracture management of volar wounds of the hand and finger. Inclusion and exclusion criteria are listed in Table 1. The results of the screening process are displayed in Figure 8. Primary endpoints were the methods of wound coverage (STSGs, FTSGs, skin substitutes, and flaps) for volar defects or contractures of the hand (palm and/or thumb/fingers).

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Volar hand wound	Dorsal hand wound
Volar finger wound	Dorsal finger wound
Volar contracture	Flap surgery
Burn injury	Animal study
Skin graft	
Skin substitute	
Integra	
Full articles	
Abstracts	
All languages	

RESULTS

Our systematic literature review uncovered 92 articles of various types (Table 2) discussing the management of volar hand and/or finger skin defects or contractures. Foreign language articles were translated by the senior author using Google Translate or iPhone's built-in translation function. Table 3 lists the number of articles derived from the 31 contributing countries, and 21 articles required translation to English from 9 foreign languages. Seventy-one articles and 40 articles reviewed primary and secondary wound coverage, respectively. Fifty articles included a focus or mention of the management of flexion contractures. There were 2 systematic reviews with one regarding the use of dermal regenerative matrix on burn patients[8] and the other comparing between STSG and FTSG on pediatric volar hand burn wounds.[9] Integra was used in 10 articles,

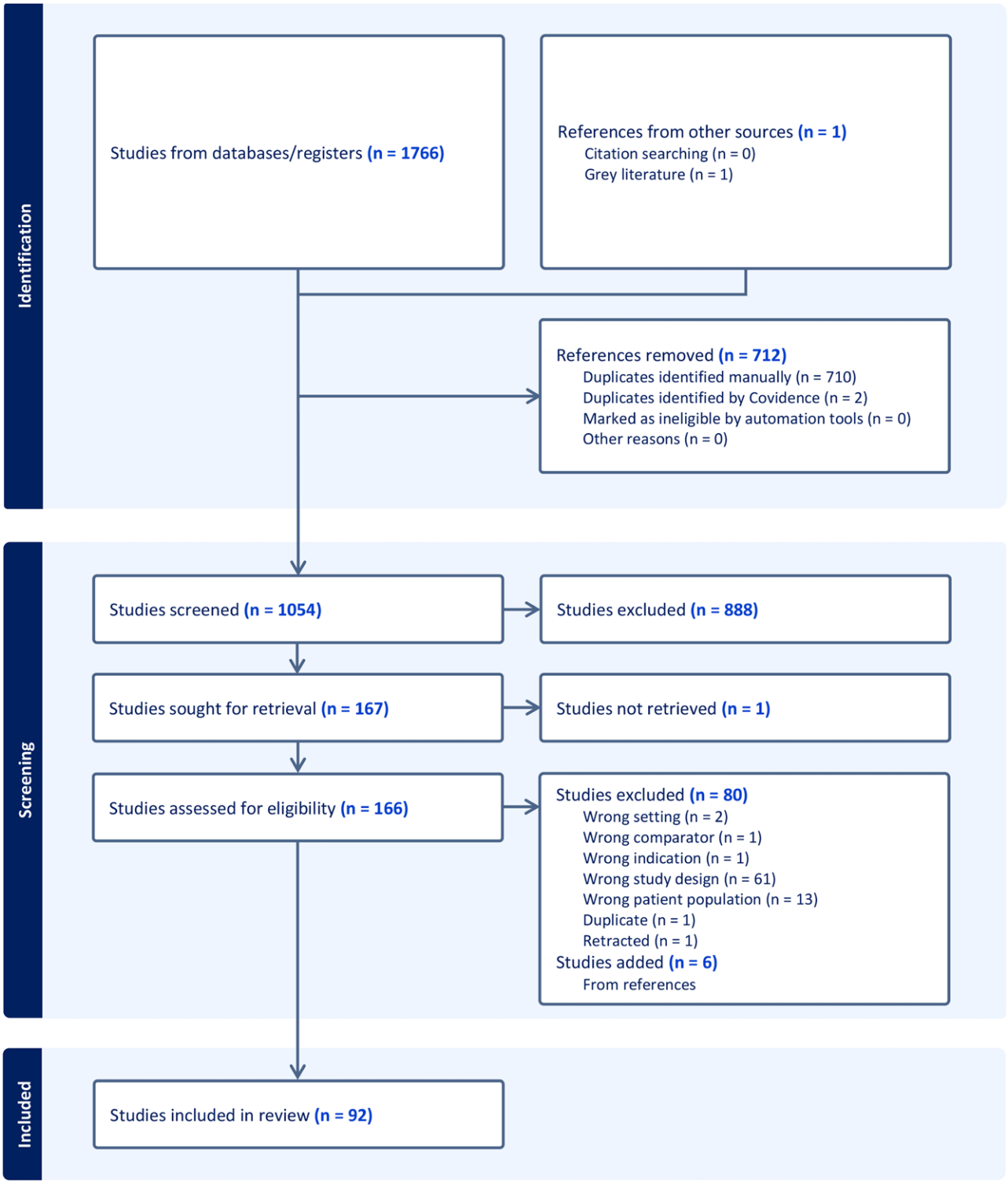

Fig. 8. PRISMA flowchart.

with only 2 articles relating to burn contractures.[10–19] Of the 92 publications, only 2 articles used the use of FTSG after the application Integra.[12,17] One was a case report of finger degloving, and the other was a case series of 21 digits with soft-tissue loss treated with Integra. Eleven articles[13,16,20–27] pertained to the use of alternative skin substitutes; only 1 of these reported on the use of subsequent FTSG, which covered 8 degloving fingers.[26] Figure 9 shows the distribution of the 92 retrieved articles based on wound coverage options discussed or showcased. Table 4 summarizes the 12 publications we found on the use of Integra as a method of coverage for wounds or skin defects following contracture

Table 2. Article Types Retrieved

Article Types	92 Publications
Systematic review	2
Randomized cohort	2
Quasi-experimental	1
Prospective comparative cohort	2
Retrospective comparative cohort	3
Multicenter cohort	1
Case series	60
Case report	11
Review, opinion, technique	7
Abstracts only	3

release involving the volar aspect of the hand, to include the palm and/or digits. One of these was a systematic review, and 2 involved the use of Integra and a second skin substitute. Two entries were abstracts only. There were no articles describing the use of FTSG with Integra for pediatric or adult postburn palmar wound or contracture.

DISCUSSION

Full-thickness burns are less common on the volar side of hands and digits compared with the dorsal aspect because of the thickness of palmar skin, its high concentration of sensory end organs, and its more protected position.[29] The method for resurfacing of the volar wound will depend of the depth of the injury, its size, deep-structure exposure, and patient factors.[30] The mainstay method of reconstruction uses skin grafting (STSG or FTSG) unless there is significant bone and/or tendon exposure. Recent data support the use of Integra and other skin substitutes for full-thickness wounds, even with exposed bone and tendon.[10,18,28] Of the skin substitute articles (21 articles), 10 used Integra. Of the articles reporting the use of skin grafting after application of skin substitute, 14.3% (3 of 21) reported using FTSG as opposed to STSG over vascularized skin substitute.[12,17,26]

A premise of utilizing Integra followed by staged skin grafting is that thin skin graft shall be used because the Integra has already promoted formation of a layer of neodermis.[2] As noted in the early study by Branski et al,[1] the donor site heals faster with thinner graft harvest in a randomized study when Integra is used in burn reconstruction compared with skin grafting alone. The composite of Integra and STSG should obviate the need for an FTSG, thus avoiding a full-thickness donor site defect, which would require STSG if it is too large to close primarily.

Table 3. Publications Distributed Based on Articles' Country of Origin and Translation Requirement

Country of Origin	No. of Articles	Required Translation	Integra	Other Skin Substitute
The USA	23	0	2	4
The UK	3	0		
Turkey	1	1		
Switzerland	1	0		
Spain	1	0		
Saudi Arabia	2	0		
Russia	1	0		
Pakistan	3	0		
Nigeria	1	0		
Morocco	1	1		
Malaysia	1	0	1	
Lebanon	1	0	1*	
Korea	5	1		1
Japan	7	3		
Italy	1	0	1	
Iran	1	0		
Indonesia	1	0		
India	1	0		
Germany	7	4		2
France	5	2	2	
Egypt	2	0	1†	1
Czechia	2	1		1
China	9	5	1	1
Canada	1	0	1	
Brazil	1	0		
Belgium	1	0	1	
Bangladesh	1	0		
Australia	4	0		
Austria	1	0		
Argentina	1	1		
Joint countries	2	0	1	1

Which countries produced article(s) on skin substitute are listed as well.
*Integra with MatriDerm in the same study.
†Integra and Pulnac in the same study.

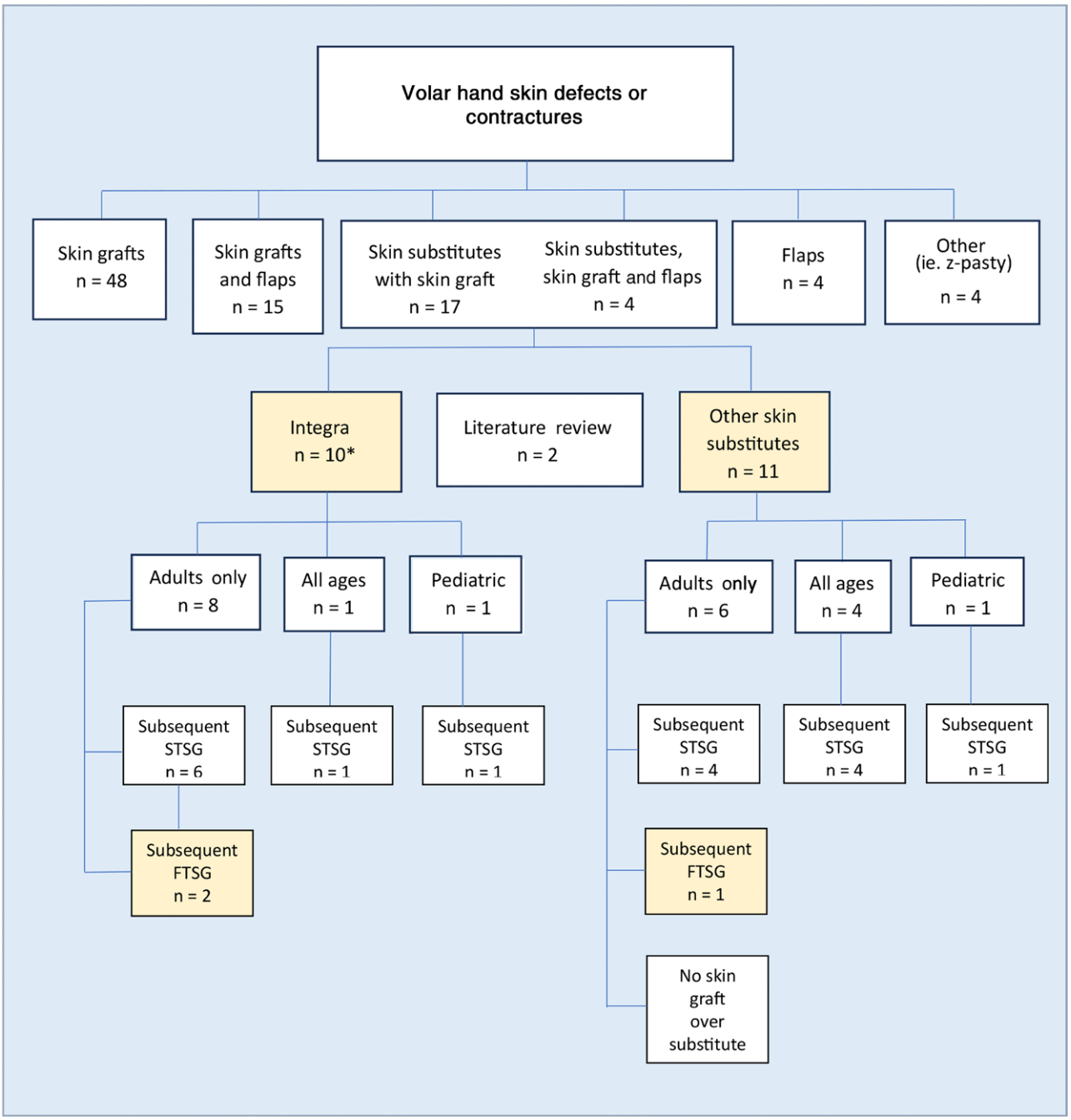

Fig. 9. Articles are categorized based on types of wound coverage discussed or demonstrated. Two retrieved publications were abstract only and were not included here.

Our patient had developed flexion contractures of both hands after STSG. Treatment of bilateral palmar contracture then failed Integra with staged STSG, which took well but rapidly developed recurrent contracture within 2 months despite splinting and hand therapy. Therefore, revision for this recalcitrant recurrent contracture was done with the use of FTSG 3 weeks after repeat contracture excision and Integra application. An FTSG combined with Integra provides skin resurfacing with a thicker dermal layer because there is neodermis provided by the Integra combined with full-thickness dermis from the FTSG. The senior author postulated that these staged co-grafts would mitigate against the patient's propensity to develop recurrent flexion contracture of his palms and digits.

The area of grafting involved a majority portion of the palm and volar aspect of the proximal right thumb and fingers of variable lengths on both hands; the patient's index and long fingers were spared from contracture on the left hand (Fig. 1). The harvesting of a large surface area of FTSG capitalized on the pliability of the skin in

Table 4. Twelve Publications Describing the Staged Application of FTSG Over Integra for Wounds of the Hand or Skin Defects Following Contracture Release of the Hand; 10 Were Full Articles

No.	Authors, Year	Study Types	N	Hand(s)	Adult	Children	Burn Skin Defects	Burn Contractures	Nonburn Skin Defects	NonBurn Contractures	Dorsal and Volar	Dorsal Only	Volar Only	Other Skin Substitute Included	STSG	FTSG
1	Dantzer et al, 2003[14]	Case series	22	29	Yes	Yes 1 contracture	15	14	0	0	Yes	No	No	No	Yes	No
2	Frame et al, 2004[19]	Retrospective multicenter case series	89	12	Yes	NR	0	12	0	0	NR	NR	NR	No	Yes	No
3	Azzena et al, 2010[12]	Case report	1	1	Yes	No	0	0	Finger degloving	0	Yes	No	No	No	No	Yes
4	Tara et al, 2010[17]	Prospective case series	17	21 Digits	Yes	No	0	0	21	0	Yes	No	No	No	No	Yes
5	Weigert et al, 2011[18]	Case series	15	15	Yes	Yes	0	0	15	0	Yes	No	No	No	Yes	No
6	Liu et al, 2014[28]	Case series	28	28	Yes	No	28	0	0	0	NR	NR	NR	No	Yes	No
7	Hicks et al, 2019[8]	Systematic review	NA	NR	Yes	Yes	215	346	0	0	NA	NA	NA	No	Yes*	No
8	Lucas et al, 2019[13]	Case series	2	2	Yes	No	0	0	2	0	Yes	No	No	MatriDerm	Yes	No
9	Hamdan et al, 2021[10]	Case report	1	1	Yes	No	0	0	1	0	0	Yes	No	No	Yes	No
10	Hillebrecht and Ziembicki, 2021[15]	Abstract of case series	17	17	Yes	No	17	0	0	0	NR	NR	NR	No	Yes	No
11	Elbadawy et al, 2021[16]	Abstract of case series	20	20	Yes	No	0	0	20	0	Yes	No	No	Pelnac	Yes	No
12	Roels and Van den hof, 2023[11]	Case report	1	1	Yes	No	0	0	4-finger degloving	0	Yes	No	No	No	Yes	No

MatriDerm (MedSkin Solution Dr. Suwelack AG, Billerbeck, Germany).
Pelnac (Gunze Co, Ltd, Kyoto, Japan).
*Cultured epidermal and keratinocyte autografts.
NA, not applicable; NR, not reported.

the groin of a toddler, thus allowing primary donor site closure. This proportionally large area of donor site skin defect usually cannot be closed primarily in an adult.

An alternative modality to mitigate recurrent contracture would be the use of skin flaps[30,31] to provide the ultimate thickness of skin because subcutaneous tissue is included. A common procedure is placing the hand in a truncal pocket with the hand released weeks subsequently, after secondary circulation has been acquired by the hand wound from the overlying skin flap; however, preventing the child from pulling the hand from the distant flap is inherently a challenge. Distal pedicle radial forearm flaps can be used but will be too bulky and require defatting and lead to forearm donor site deformity. Free tissue transfers (free flaps), which are generally bulky, can also be used, but such operations are technically demanding on a young pediatric patient and the donor site deformities are not insignificant.[12] Thinner free flaps are available, such as the medialis pedis,[32] but were not entertained due to patient's young age and potential untoward effects on his gait development, because the large flap harvest would encroach on the weight bearing area of his sole.

For his repeat surgical intervention, we used a much longer duration of transarticular skeletal fixation. Kirschner fixation across finger joints is an established modality to prevent flexion contracture soon after a burn injury and during grafting.[33,34] Pin fixation lasted approximately 9 weeks for his right long, ring, and small fingers and 16 weeks for left ring and small finger. Left-handed pins were retained unfavorably longer than planned because of the child contracting COVID-19. Joint plasticity despite long transarticular skeletal fixation in a young child was anticipated. Along with possible damage to growth centers, infection and joint stiffness are known risks with transarticlar fixation.[33] An extended length of skeletal pin immobilization was used, given his history of severe contracture recurring within two months of Integra followed by STSG performed previously by another surgeon. A safe duration of internal fixation of finger in both the adult and pediatric patient has not been well established due to the paucity of reports regarding the duration of its use and long-term follow-up. Achauer et al[33] reported that 4 weeks of pin immobilization is well tolerated by almost all of his burn patients, but joint stiffness occurs at 6 weeks.

Figures 4–7 show satisfactory hand function at 1 ½ years after completion of surgical intervention. He still has a moderate flexion contracture of his left small finger, but bilateral hand function remains satisfactory. One must consider the likelihood that a regional or distant skin flap could have prevented such recurrence in contracture, as skin flaps remain the gold standard for coverage after contracture release in the pediatric patient. Close follow-up is undertaken by the pediatric hand service, as future development of flexion contracture is expected due to rapid skeletal growth.

CONCLUSIONS

This case report suggests that the application of FTSG instead of STSG to vascularized Integra offers protective value against recurrent burn contracture of the palmar hand. Our literature review confirmed the rarity of this treatment modality for resurfacing volar hand skin defects and coverage after palmar burn contracture release. We conclude that more studies and long-term follow-up, especially in the pediatric patient, are needed.

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DISCLOSURE

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

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