Reconstruction of a Recurrent First Dorsal Web Space Defect using Acellular Dermis

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Abstract Oncologic defects of the hand can be problematic for the reconstructive surgeon. These defects may require a delay in definitive coverage until clear margins of resection can be obtained, which can result in a prolonged period of painful dressing changes and increased risk of soft-tissue infection. In addition, reconstructive options for oncologic defects are often limited to skin grafting, which can yield functional deficits secondary to contracted healing. Currently, there is no definitive method for preventing skin graft contracture; however, acellular dermis has been proposed as a biomechanical scaffold to enhance subsequent skin graft healing and slow this functionally debilitating process. Here, we present a patient with recurrent melanoma of the first dorsal web space. After re-resection of the melanoma, the 11 cm×5 cm defect was reconstructed using acellular dermis as temporary coverage to allow ample time for permanent section results. Ten days later, after confirming negative margins of resection, a split-thickness skin graft (STSG) was applied over the vascularized neo-dermis. Follow-up clinical examination and the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaires were used to assess outcome. At 7 months, the patient had no recurrence of melanoma and a DASH functional reduction of only 6.9%. After approximately 18 months, the patient's

wounds had healed with excellent cosmetic and functional results, without any evidence of a web space contracture. These observations suggest that acellular dermis is a useful adjunct for wound coverage of the hand, particularly in areas of functional importance, such as the first dorsal web space.

Keywords Acellular dermis · Skin cancer of the hand · Reconstruction of the hand · Re-resection · Web space

Introduction

Skin cancer is the most common form of cancer in the United States, with an estimated 1.3 million new cases being diagnosed this year alone [2, 36]. Skin cancer can be divided into three main types: melanoma, basal cell carcinoma (BCC), and squamous cell carcinoma (SCC). Although melanoma represents only a small percentage of all skin cancers, it is responsible for nearly 74% of all skin cancer-related deaths [2]. The incidence of melanoma is currently rising faster than that of any other cancer [36]. Of the non-melanoma skin cancers (NMSCs), BCC is nearly four times as prevalent as SCC [36].

Skin cancer generally occurs in areas of increased sun and UV radiation exposure, such as the face, scalp, neck, and back. Skin cancer of the hand is rare, and thus, there are few investigations focusing specifically on the behavior and outcome of skin cancers in this area [25, 33, 45]. In 1993, Chakrabarti et al. [11] reported that nearly 75% of all skin cancers of the hand were SCCs. This finding is contradictory to the prevalence of skin malignancies occurring elsewhere on the body, where BCC prevails. Melanoma is still quite rare and occurs in only 3% of cases [4, 5, 9, 16, 18, 21]. Schiavon et al. reported that the majority of SCCs

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occur on the dorsum of the hand, while melanoma occurs commonly within the first dorsal web space [32].

With a reported recurrence rate and metastasis rate of 22 and 28%, respectively [12], skin cancer of the hand requires early, aggressive surgical management. Surgical resection within the hand can be dangerous because of the risk for postoperative functional deficits. Of particular importance is the first dorsal web space, which contains structures intimately involved in thumb extension, abduction, and opposition, as well as thumb–index finger pinch. These functions are reliant on the preservation of durable, pliable tissue within the first dorsal web space [42]. Thus, excision of large cancers requiring wide margins of resection, can lead to significant defects [7, 17, 37].

Traditionally, these oncologic defects have been approached using the principles of the reconstructive ladder, including the use of STSGs, full-thickness skin grafts (FTSG), local flaps, pedicled flaps, and free flaps. It is imperative that hand functionality be preserved when considering reconstructive options. For example, in anatomic zones of high functionality, skin grafts can be deleterious as a result of contracture. In addition, for larger defects, local flaps may be inadequate, and pedicled flaps may impart excess bulk within the area [3, 27, 35, 38, 47].

Case Report

The patient is a 79-year-old, right hand-dominant female, who developed a recurrent malignant melanoma of the right thumb and first dorsal webspace. The patient's melanoma was Clark level IV, with a Breslow thickness of 0.54 mm. The melanoma was re-resected, and the patient was reconstructed at that time using a FTSG from the anterior aspect of her right forearm. Unfortunately, on permanent section results, the patient was noted to have a positive margin and thus required additional margin resection. After this third resection, the defect measured approximately 11 cm×5 cm in size. Reconstruction of this defect was performed in two stages. During the primary stage, the defect was covered using acellular dermis (Alloderm®, LifeCell Corporation, Branchburg, NJ). The patient subsequently underwent skin grafting 10 days later for definitive coverage.

The acellular dermis was prepared according to the manufacturers' guidelines. The tissue was removed from the packaging and placed in a sterile kidney dish, where it was submerged in 100 ml of room temperature, sterile normal saline. The initial washing lasted for approximately 30 min. The dermis was then transferred to a new sterile dish, and washed in similar fashion, for an additional 5 min. After the washing period, the dermis was soft, pliable, and ready for use.

While the acellular dermis was being prepared, meticulous hemostasis was established within the wound bed

using the electrocautery device. Immediately before the application of the dermis, the wound bed was irrigated with a sterile saline solution containing epinephrine, to ensure that hemostasis was adequate.

The non-meshed acellular dermis was trimmed to approximate the defect and was secured into place using 3-0 running and interrupted chromic sutures (Fig. 1). At the end of the procedure, a bolster dressing was applied. After 10 days, the dressing was removed, and a thin, 12/1000th inch, STSG was grafted over the neo-dermis. Again, a bolster dressing was applied, and the patient's hand was splinted for approximately 2 weeks to prevent excess movement and graft shear.

Postoperatively, the patient did well. She had approximately 100% take of her skin graft. She was followed on a routine basis for oncologic surveillance and functional

Figure 1 a–b Intraoperative images detailing, **a** application of acellular dermis within the first web space and **b** appearance of hand after completion of the acellular dermis reconstruction.

assessments using the DASH questionnaire. At her 7-month follow-up appointment, she was noted to have full range of motion of her thumb and hand, with a DASH functional reduction of only 6.9%. Clinical assessment of hand function and strength at 18 months follow-up was excellent. She had near complete opposition of her thumb and fifth digit (Fig. 2). Cosmetically, the patient's first dorsal web space was symmetrical bilaterally in both appearance and thickness. Her metacarpo-phalangeal (MCP) and interphalangeal (IP) joint flexion, and intrinsic hand motor strength, were minimally reduced on the right side, when compared to her left hand. Conversely, her grip strength was 5 lbs greater in the right hand (Table 1). The patient had only mild sensory deficit along the radial distribution on the dorsal aspect of the thumb.

Figure 2 a–b Images at approximately 12 months postoperatively detailing **a** cosmetic results and **b** thumb–finger opposition indicating good functional results.

Table 1 Hand strength comparison at 18 months follow-up after resection and reconstruction of recurrent first dorsal web space melanoma.

Parameters	Right Hand (Treated)	Left Hand (Control)
Active flexion of MCP joint (degrees)	0/40	0/50
Active flexion IP joint (degrees)	0/25	0/45
Pinch strength (pounds)	7 lbs	12 lbs
Grip strength (pounds)	55 lbs	50 lbs

MCP Metacarpo-phalangeal, *IP* interphalangeal

Discussion

Reconstruction of recurrent first dorsal web space defects poses a set of complex oncologic and functional challenges for the hand surgeon. Large and/or recurrent skin malignancies in this area may yield full-thickness wounds that are substantial in magnitude [42]. From an oncologic standpoint, the possibility of margin positive resections on final pathology creates a potential problem for immediate reconstruction of these defects; positive margins necessitate takedown of the reconstruction, re-excision, and a secondary reconstruction. In recurrent lesions, in particular, the possibility of having positive margins is even higher. [6, 10] The functional outcome of such defects is predicated on the use of durable and pliable tissue for reconstruction [7, 17, 37]. These criteria can be difficult to achieve for larger defects, where local skin flaps are of limited use, and pedicled forearm flaps can provide excess tissue bulk [3, 27, 35, 38, 47].

In most oncologic resections, the specimen is first sent for frozen section before proceeding with any form of reconstruction. Although frozen sections may increase the likelihood of a margin free resection, there is a reasonable error rate when ultimately compared to permanent section. The frozen section technique is reported to have an accuracy of approximately 71–99% [13, 15, 24, 41]. Nield et al. found extensive histological differences when comparing frozen sections versus their permanent paraffin embedded counterparts, prompting their recommendation to base surgical margins and prognosis off of permanent section results and not the frozen section [23]. Based on the above findings, and due to the increased risk of positive margins in recurrent malignancies, it is reasonable to approach recurrent lesions with a, resect and wait, mentality, thereby avoiding the potential loss of first-line reconstructive options.

Since 1992, acellular dermis has been used in multiple settings, including burn reconstruction, soft tissue augmentation, abdominal hernia repair, skin and tympanic membrane grafting, and nasal septal reconstruction [1, 8, 14, 28, 34, 43, 46]. Alloderm® is an acellular human tissue matrix derived from cadaveric dermis. It serves as a biomechanical scaffold, enabling angiogenesis, cellular migration, and integration into host tissue. Furthermore, it preserves major

components of the dermal cytoskeleton, such as elastin and collagen fibers, creating an intact basement membrane complex. After incorporation into the host tissues, the acellular dermis will initiate a myriad of cellular events leading to tissue in-growth and reconstitution as a vascularized neo-dermis [19]. This neo-dermis is then amenable to skin grafting for definitive defect closure.

In the aforementioned setting, the strategy of delaying immediate reconstruction for recurrent skin cancer can lend itself to the use of acellular dermis as the initial reconstructive measure. Acellular dermis can be applied to the wound defect immediately after resection, allowing the surgeon ample time to wait for permanent section results; this would preclude the need for inconvenient, and sometimes painful, daily dressing changes required in cases where immediate reconstruction is avoided altogether. In the event that margins are positive and an additional resection is required, there is no inherent loss of skin graft or local flaps. The alloderm sheet is simply removed, new margins are resected, and this reconstructive process repeats until free margins are obtained. If, and when, the margins are negative, the acellular dermis then provides a vascularized neo-dermis, which can enhance subsequent skin grafting and minimize wound contracture.

There is abundant data, primarily within the burn literature, to suggest that the application of dermal substitutes to full-thickness defects, before skin graft reconstruction, reduces the incidence of post-graft contracture [26, 43]. Although other dermal substitutes have been successfully used in this setting, a recent comparative study by Truong et al. suggests that the acellular dermal matrix products are superior with regard to contracture inhibition [39]. Tsai et al. investigated the use of acellular dermis in the reconstruction of burn wounds over joints. This study found that, at 1 year post-reconstruction, patients had a nearly normal range of motion (average 95% of normal) [40].

The myofibroblast is known to be the major cellular factor involved in the development of wound contracture. In 1977, Rudolph et al. [30] found that the life cycle of these cells within a wound, parallels the time span required for wounds to contract. Thus, one of the major differences between wounds that heal with normal scarring and those that go on to develop contracture or hypertrophy, is related to the persistence of the myofibroblast population [22]. Transferred skin grafts intrinsically inhibit wound contraction as a result of accelerating the life cycle of myofibroblasts, thereby, decreasing the total number within the grafted wound [29, 31]. Reports have indicated superior wound contracture inhibition when dermal substitutes are used in conjunction with grafting [26, 39, 43, 44]. Dermal substitutes may aid contracture inhibition by providing a larger quantity of viable dermal collagen matrix within the recipient bed before skin grafting [20].

With regard to our patient, the acellular dermis provided an excellent alternative to dressing changes as we waited for permanent section results. In addition, a durable and vascularized neo-dermis was formed, imparting an excellent recipient bed for a STSG. In this setting, the STSG provided reliable coverage to a highly motion-sensitive area without the functional limitations of graft contracture and/or the morbidity of a more invasive and complex reconstruction. At 18 months out from the procedure, the patient had excellent hand function and cosmesis. The reconstructed web space was similar to the left hand in appearance and overall thickness. The patient's intrinsic hand motor deficits were minimal, and her overall grip strength was actually superior to the non-treated hand.

Although there are no direct cost comparison studies regarding the use of Alloderm in this setting, one could argue that its use would likely prove cost-effective. The use of Alloderm for defect coverage during the initial reconstruction not only limits the inconvenience, pain, and expense of daily dressing changes, it also prevents the morbidity of more invasive procedures, which would be lost if resected margins were positive. Likewise, if initial margins of resection are negative, a less invasive procedure can be employed with excellent functional results.

Conclusion

Acellular dermis provides an effective option in the management algorithm of recurrent oncologic defects within functionally important anatomic regions, such as the first dorsal web space of the hand. It serves as adequate, temporary wound coverage until margin free resection can be confirmed and provides a highly vascularized neo-dermal bed amenable to skin grafting. In addition, the acellular dermis enhances the skin graft and effectively reduces the risk of post-graft contracture, leading to excellent functional and cosmetic results.

References

1. Achauer BM, VanderKam VM, Celikoz B, et al. Augmentation of facial soft-tissue defects with Alloderm dermal graft. *Ann Plast Surg* 1998;41:503–7.
2. American Cancer Society. Cancer Facts and Figures 2007. Available at: <http://www.cancer.org>. Accessed on February 15, 2007.
3. Bardsley AF, Soutar DS, Elliot D, et al. Reducing morbidity in the radial forearm flap donor site. *Plast Reconstr Surg* 1990;86:287–92.
4. Bean DJ, Rees RS, O'Leary JP, et al. Carcinoma of the hand: a 20-year experience. *South Med J* 1984;77:998–1000.
5. Bogumill GP, Sullivan DJ, Baker GI. Tumors of the hand. *Clin Orthop* 1975;108:214–22.
6. Breuninger H, Dietz K. Prediction of subclinical tumor infiltration in basal cell carcinoma. *J Dermatol Surg Oncol* 1991;17: 574–8.

7. Brodland DG, Zitelli JA. Surgical margins for excision of primary cutaneous squamous cell carcinoma. *J Am Acad Dermatol* 1992;27:241–8.
8. Butler CE, Prieto VG. Reduction of adhesions with composite AlloDerm/polypropylene mesh implants for abdominal wall reconstruction. *Plast Reconstr Surg* 2004;114:464–73.
9. Butler ED, Hamill JP, Seipel RS, et al. Tumors of the hand. A ten-year survey and report of 437 cases. *Am J Surg* 1960;100:293–302.
10. Cataldo PA, Stoddard PB, Reed WP. Use of frozen section analysis in the treatment of basal cell carcinoma. *Am J Surg* 1990;159:561–3.
11. Chakrabarti I, Watson JD, Dorrance H. Skin tumours of the hand. A 10-year review. *Br J Hand Surg* 1993;18:484–6.
12. Dantzer E, Braye FM. Reconstructive surgery using an artificial dermis (Integra): results with 39 grafts. *Br J Plast Surg* 2001;54:659–64.
13. DiNardo LJ, Lin J, Karageorge LS, et al. Accuracy, utility, and cost of frozen section margins in head and neck cancer surgery. *Laryngoscope* 2000;110:1773–6.
14. Downey TJ, Champeaux AL, Silva AB. AlloDerm tympanoplasty of tympanic membrane perforations. *Am J Otolaryngol* 2003;24:6–13.
15. Gephardt GN, Zarbo RJ. Interinstitutional comparison of frozen section consultations. A college of American Pathologists Q-Probes study of 90,538 cases in 461 institutions. *Arch Pathol Lab Med* 1996;120:804–9.
16. Graham WP 3rd, Davis TS, Miller SH. Malignant tumors of the upper extremity: 1971 to 1976. *Clin Plast Surg* 1980;7:413–20.
17. Hauschild A, Rosien F, Lischner S. Surgical standards in the primary care of melanoma patients. *Onkologie* 2003;26:218–22.
18. Kendall TE, Robinson DW, Masters FW. Primary malignant tumors of the hand. *Plast Reconstr Surg* 1969;44:37–40.
19. Kim J, Basu B, Bienstock A, et al. A Novel Method of Urethral Reconstruction Using Doubly-Grafted Dermal Flaps Derived from Acellular Dermis. Palm Springs, CA: American Society of Reconstructive Microsurgery; 2004.
20. Lamme EN, Van Leeuwen TJ, Brandsma K, et al. Higher numbers of autologous fibroblasts in an artificial dermal substitute improve tissue regeneration and modulate scar tissue formation. *J Pathol* 2000;190:595–603.
21. Lawrence EA, Dickey JW, Vellios F. Malignant tumors of the soft tissues of the extremities. *Arch Surg* 1953;67:392–401.
22. Nedelec B, Ghahary A, Scott PG, et al. Control of wound contraction. Basic and clinical features. *Hand Clin* 2000;16:289–302.
23. Nield DV, Saad MN, Khoo CT, et al. Tumour thickness in malignant melanoma: the limitations of frozen section. *Br J Plast Surg* 1988;41:403–7.
24. Ord RA, Aisner S. Accuracy of frozen sections in assessing margins in oral cancer resection. *J Oral Maxillofac Surg* 1997;55:663–9.
25. Quinn MJ, Wikramanayake R, Thompson JF, et al. Non-subungual melanomas of the hand. *Brit J Hand Surg* 1992;17:433–6.
26. Rennekampff HO, Kiessig V, Griffey S, et al. Acellular human dermis promotes cultured keratinocyte engraftment. *J Burn Care Rehabil* 1997;18:535–44.
27. Richardson D, Fisher SE, Vaughan ED, et al. Radial forearm flap donor-site complications and morbidity: a prospective study. *Plast Reconstr Surg* 1997;99:109–15.
28. Romo T 3rd, Sclafani AP, Sabini P. Reconstruction of the major saddle nose deformity using composite allo-implants. *Facial Plast Surg* 1998;14:151–7.
29. Rudolph R. Inhibition of myofibroblasts by skin grafts. *Plast Reconstr Surg* 1979;63:473–80.
30. Rudolph R, Guber S, Suzuki M, et al. The life cycle of the myofibroblast. *Surg Gynecol Obstet* 1977;145:389–94.
31. Rudolph R, Suzuki M, Guber S, et al. Control of contractile fibroblasts by skin grafts. *Surg Forum* 1977;28:524–5.
32. Schiavon M, Mazzoleni F, Chiarelli A, et al. Squamous cell carcinoma of the hand: fifty-five case reports. *Am J Hand Surg* 1988;13:401–4.
33. Scrivener Y, Grosshans E, Cribier B. Variations of basal cell carcinomas according to gender, age, location and histopathological subtype. *Br J Dermatol* 2002;147:41–7.
34. Sinha UK, Shih C, Chang K, et al. Use of AlloDerm for coverage of radial forearm free flap donor site. *Laryngoscope* 2002;112:230–4.
35. Swanson E, Boyd JB, Manktelow RT. The radial forearm flap: reconstructive applications and donor-site defects in 35 consecutive patients. *Plast Reconstr Surg* 1990;85:258–66.
36. The Skin Cancer Foundation. Skin Cancer Facts. Available at: <http://www.skincancer.org/skincancer-facts.php>. Accessed on February 15, 2007.
37. Thomas DJ, King AR, Peat BG. Excision margins for non-melanotic skin cancer. *Plast Reconstr Surg* 2003;112:57–63.
38. Timmons MJ, Missotten FE, Poole MD, et al. Complications of radial forearm flap donor sites. *Br J Plast Surg* 1986;39:176–8.
39. Truong AN, Kowal-Vern A, Latenser BA, et al. Comparison of dermal substitutes in wound healing utilizing a nude mouse model. *J Burns and Wounds* 2005;4:72–81.
40. Tsai CC, Lin SD, Lai CS, et al. The use of composite acellular alodermis-ultrathin autograft on joint area in major burn patients—one year follow-up. *Kaohsiung J Med Sci* 1999;15:651–8.
41. van der Meer GT, Willemse F, Marck KW. Low 5-year recurrence rate after surgical excision of 126 basal cell carcinomas with frozen section analysis upon indication. *Ned Tijdschr Geneesk* 2001;145:1409–13.
42. Van Winkle W Jr. Wound contraction. *Surg Gynecol Obstet* 1967;125:131–42.
43. Wainwright DJ. Use of an acellular allograft dermal matrix (AlloDerm) in the management of full-thickness burns. *Burns* 1995;21:243–8.
44. Walden JL, Garcia H, Hawkins H, et al. Both dermal matrix and epidermis contribute to an inhibition of wound contraction. *Ann Plast Surg* 2000;45:162–6.
45. Warso M, Gray T, Gonzalez M. Melanoma of the hand. *Am J Hand Surg* 1997;22:354–60.
46. Wax MK, Winslow CP, Andersen PE. Use of allogenic dermis for radial forearm free flap donor site coverage. *J Otolaryngol* 2002;31:341–5.
47. Werle AH, Tsue TT, Toby EB, et al. Osteocutaneous radial forearm free flap: its use without significant donor site morbidity. *Otolaryngol Head Neck Surg* 2000;123:711–7.