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CASE REPORT
Reconstructive

Keystone Flap Type IIIB: A New Variation for Coverage of Defects at Joint Regions

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Summary: Soft tissue defect reconstruction at joint regions is a challenging problem due to the sparse excessive tissue and late complication of constrigent scar formation. Priorly irradiated tissue, often the case in sarcoma patients, is especially problematic. The keystone design perforator island flap is safe and reliable. We now present a new keystone flap design, which is particularly suitable for the reconstruction of large soft tissue defects at joint regions. It provides a cutaneous component without the need for a skin graft and therefore minimizes the risk of contracture. Donor site morbidity is negligible. Furthermore, it offers a favorable aesthetic result compared to other flaps, eg, a muscular flap. We propose a new keystone flap design as an extension of Behan's classification, the Keystone flap type IIIb. *(Plast Reconstr Surg Glob Open 2021;9:e3450; doi: 10.1097/GOX.0000000000003450; Published online 23 March 2021.)*

The Keystone Design Perforator Island Flap (KDPIF) was first described by Behan et al. in 2003[1] as a surgical technique for defect closure after skin cancer excision. It is an adaptation of the "Bezier type flap."[2] The flap design resembles the keystone of Roman arches. It is a local fasciocutaneous advancement perforator flap based on the underlying angiosomes that makes use of the choke vessels between them. No perforator mapping is necessary. Donor site closure is achieved in a double V-to-Y manner. Four subtypes have been described depending on whether the deep fascia is incised or not (no incision with type I), if skin grafting to the donor site is necessary (type IIa: no skin grafting; type IIb: with skin grafting), if 2 opposing flaps are used (type III), and if partial flap undermining is used (type IV).[1] The versatility and reliability of these flaps have been well documented.[1,3–6]

We propose a new keystone flap design as an extension of Behan's classification, which we have found to be particularly suitable for the joint regions.

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CASE REPORT

Our patient was a 30-year-old woman with persisting knee pain following trauma that occurred 7 years earlier. An MRI scan showed a tumor of the iliotibial tract, and the patient was diagnosed with prepatellar bursitis. A bursectomy was performed. However, the biopsy revealed a R1-resected biphasic synovial sarcoma. The further staging showed no metastasis. Preoperative radiation therapy with a total of 50.4 Gy was performed and finished 6 weeks before the operation.

A local wide re-excision with a 2-cm safety margin was performed, which included resection of the lateral retinaculum and parts of the vastus lateralis muscle and parts of the joint capsule. This resulted in an 11 × 7 cm defect laterally at the knee joint. To leave the extensor aspect of the knee untouched and because there was skin laxity at both the mediodorsal and the proximal anterior aspect of the defect, we decided to close the defect by modifying a type III keystone flap based on the angiotomes of the descending genicular artery (ventrally) and superior lateral genicular artery (laterally). This variation differs from the original type III flap because the flaps were shifted against each other in an oblique alignment, leaving the extensor side of the knee untouched. Furthermore, the flaps were positioned in opposing corners of the defect, not reaching to the other corner but ending at two thirds along the long side of the defect. Additional length was gained this way (Fig. 1). Adjusted to the anatomic region in this case, the ventral flap was designed shorter to leave the patella untouched. Also, the dorsal flap was adjusted to the local tissue laxity.

Like with the original type III keystone flap, the short axes of the flaps run perpendicular to the defect border,

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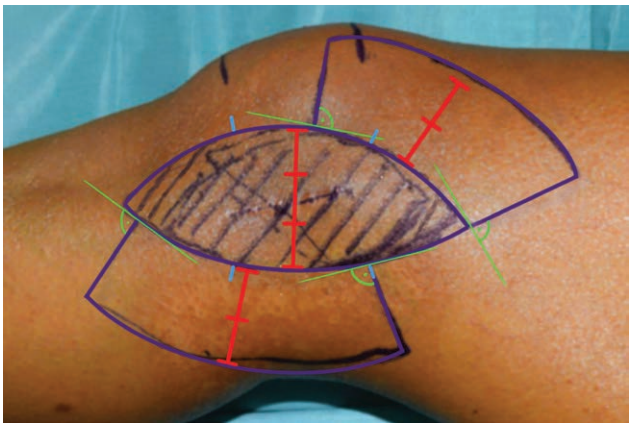

Fig. 1. Photograph of the markings before skin incision. Overlayed is the flap design: opposing keystone flaps. The flaps are positioned in opposing corners of the defect; the dorsal one was slightly cranialized due to local skin laxity. The long flap axis ends two thirds along the long side of the defect (the ventral flap in this case was designed shorter to leave the patella untouched). Short axes of the flaps run perpendicular to the defect border, and flap width is at least two-thirds the width of the defect.

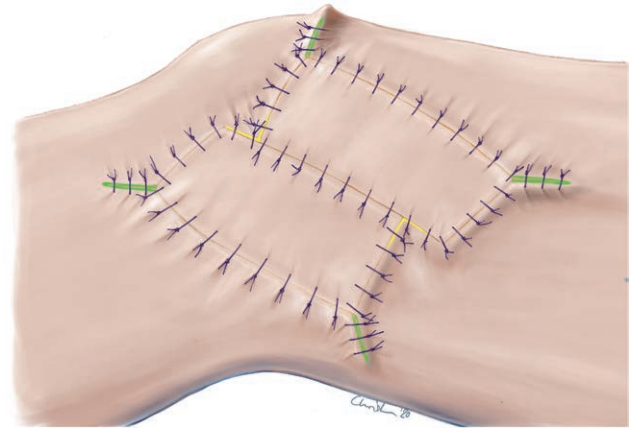

Fig. 2. Drawing of the flaps after set-in, illustrating the V-Y advancement.

Fig. 3. Final clinical result 6 months after surgery.

and the flap width must be at least two thirds the width of the defect. Blunt dissection down to the fascia and circumferential incision of the fascia were performed. The flaps were not undermined. The flaps were then advanced in a V-to-Y fashion and additional rotation with the defect's vertexes being the pivot points (Fig. 2). The donor site closure in this case was achieved without any skin grafting.

A minor dog ear at the ventral distal V-Y aspect dissolved spontaneously within 3 weeks after the surgery (Fig. 3). A follow-up 6 months postoperatively showed anesthesia of the distal flap pole without any wound healing or flap complications, and knee movement was 120 degree-0 degree-0 degree flexion/extension, as it had been preoperatively.

DISCUSSION

Keystone perforator island flaps combine the safety and reliability of perforator flaps with the simplicity, efficacy, and low donor site morbidity of local flaps. They can be used in almost every part of the body for a variety of defects, ranging from superficial small defects to large defects with exposed prominent structures.[7,8] It was also shown that keystone island flaps can be safely used in irradiated tissue[9] and for defects following the resection of melanotic and non-melanotic skin cancer,[5] as well as sarcoma.[7] Major complications, such as partial or total flap loss, are rare, ranging from 0% to 5%.[1,8,10] Nevertheless, reconstruction of the joint regions remains a challenging task, given the sparse excessive tissue and the late complication of constringent scar tissue.

This new keystone flap variation is capable of covering large defects at delicate joint regions such as the knee joint, which, to our knowledge, has never been published in the literature before. By shifting the 2 opposing flaps against each other, we were able to spare the soft tissue of the extensor side of the knee, where scarring can lead to feelings of tension, aesthetically unfavorable broadened scars, and even an impaired range of motion.

Also, other locoregional flaps are potentially suitable for closure of the presented defect. A muscle flap, such as gastrocnemius, though, holds the disadvantage of weakening or even sacrificing the used muscle. Large rotation flaps may bear greater donor site morbidity. Our flap design provides a cutaneous component without the need for skin grafting, and therefore has a lower risk of contracture at the joint and likely better aesthetic results. All the mentioned techniques are fast, straight forward, versatile, reliable, and safe.

Therefore, we suggest an addition to the known Behan classification: keystone flap type IIIb—2 large keystone perforator flaps aligned in an oblique way to preserve the anatomical and functional features of joint regions. Classic type III flaps could be called type IIIa (Fig. 4).

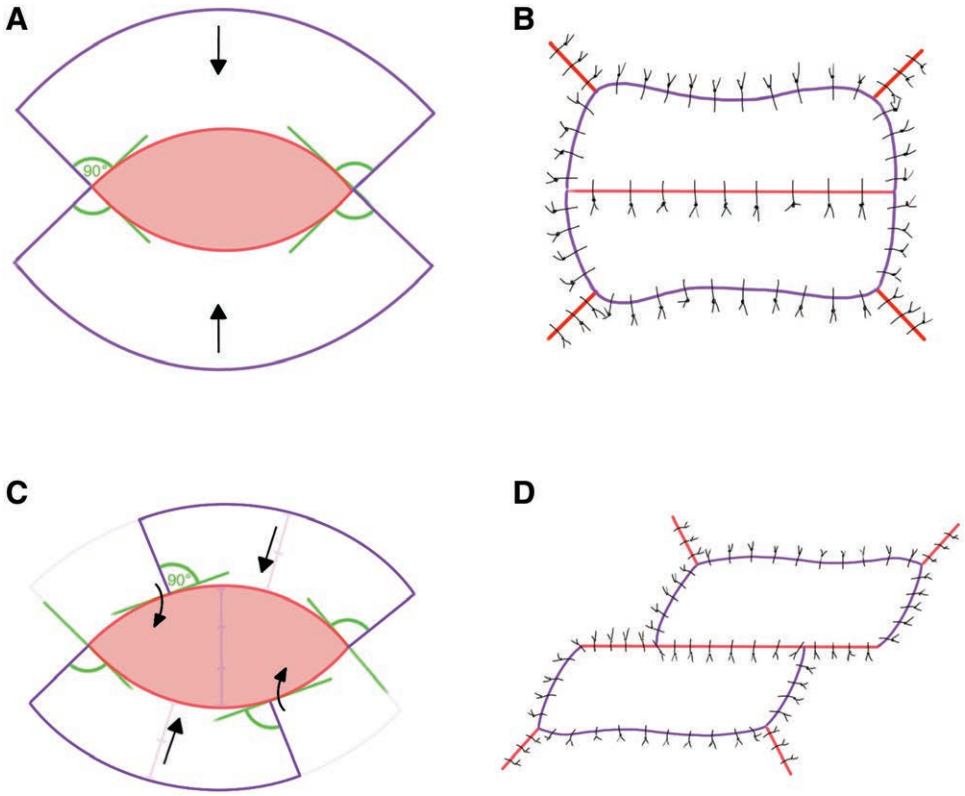

Fig. 4. Schematic comparison of type IIIa and IIIb flaps: the type III keystone perforator island flap described by Behan (A, B) and our suggested variation of the flap (type IIIb) (C, D).

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