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SURGICAL TECHNIQUE

A New Incision Technique to Reduce Tibiofemoral Mismatch in Rotationplasty

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Abstract Rotationplasty provides stable and durable biologic reconstruction after tumor resection around the knee and renders reliable results, in young patients. However, after resection of the tumor, there is often a mismatch between the circumference of the proximal (femoral) and the distal (tibial) parts. Because rotationplasty includes an intercalary amputation where the ends are readapted, there is always a mismatch of the proximal and distal circumferences of the soft tissue envelope. To facilitate skin closure without tension and to avoid impaired wound healing and subsequent infections, the type of incision is critical and must be carefully planned. We present a new incision technique for rotationplasty about the knee. Half of the difference of the incision length of the proximal and distal circumferences represents the base of the triangle proximally, medially and laterally of the thigh. After adapting both ends, the peak of this flat triangle is distally adapted via a vertical incision which allows it to match unequal circumferences. This technique was used in eight patients, in all of whom the wounds healed uneventfully.

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Introduction

Rotationplasty was first described in 1930 by Borggreve for treatment of a shortened limb with ankylosis of the knee after tuberculosis [1]. In 1948, Van Nes described its use for treatment of congenital defects of the femur [17]. In the 1980s, Kotz and Salzer [11] and Salzer et al. [16] reported treating patients with malignant tumors around the knee by rotationplasty as an alternative to above-knee amputation. Today, rotationplasty is one option for surgical management of musculoskeletal tumors, particularly in children [2, 3, 8, 18] or as a salvage option after failed reconstruction [4, 5, 13]. Overall function reportedly is excellent [4, 10, 15]. There have been no problems with wound healing. Patients are able to bear their full weight, actively control the knee in coordinated gait patterns, and walk without assistive devices.

Different incisions have been described. Originally, two elliptical or oval circumferential incisions were described to produce a rhomboidal area of skin to be resected with the tumor mass [1]. However, this incision technique causes difficulties with later skin closure because of the mismatch of the amount of skin of the proximal and distal parts. Consequently, a fish-mouth–shaped incision of the proximal, ie, the femoral part, was proposed by Gebhart et al. in 1987 [6]. The calf is viewed as a cylinder with the circumference at the level of the intended distal resection. Then, the circumference of the intended proximal thigh resection is projected onto the cylinder and angled until the shadows of both circumferences meet. A height is defined by the angle of obliquity and diameter of the thigh and calf circumferences. This height represents the depth of the incision medially and laterally on the leg, which is used to produce the fish-mouth–shaped distal incision. However, there is often the problem of proximal nonfitting.

To overcome the main disadvantages of these incision techniques, we describe a new incision technique for the Borggreve/Van Nes rotationplasty and briefly describe the eight patients in whom this incision was used.

Surgical Technique

With the patient supine, the levels of the skin incision are determined based on the exact dimension of the tumor as assessed by preoperative diagnostic imaging and planning to ensure safe margins. At the end of growth, the center of rotation of the rotated ankle should be at the same level as the center of rotation of the contralateral knee accepting that the rotated limb initially is longer than the contralateral, uninvolved limb to compensate for the remaining growth discrepancy. We acknowledge that some surgeons favor a technique which adjusts the limb length at surgery even in young children.

A sterile cord is used to measure the circumference of the planned distal incision. It is laid around the leg, thereby representing the entire length of the distal incision (Fig. 1). This cord subsequently is used to match the circumference of the distal and proximal parts. For this purpose, it is cut in half and laid on the anterior and posterior circumferences of the planned proximal incision, leaving two equally sized gaps medially and laterally (Fig. 1). The resulting distance between the anterior and posterior parts is connected by a symmetric freehand triangular-shaped incision of equal size at both sides (Fig. 2). In turn, at the distal site, a straight lateral and medial incision representing the height of the proximal triangle is made. As such, the proximal soft tissue spindle adapts into the distal enlarged or spread incision to perfectly accommodate for the difference at the circumferences. These can be enlarged later according to the needs as given by the proximal triangles to match both parts (Fig. 3).

The surgical technique after skin incision and preparation of the subcutaneous tissue has been presented in detail [5]. It is important to fix the plate not too far laterally or ventrally to prevent the limb from rotating too much laterally and furthermore, to assure the heel is in the neutral position of the foot (90° flexion) that corresponds to the level of the contralateral knee. It is important to reattach the gastrocnemius muscles as proximally as possible to the anterior fascia of the femur in the neutral position of the foot. Finally, the skin then is adapted under slight pressure thereby avoiding leaving an over length, which later would lead to an unfavorable appearance and difficulties with the prosthesis.

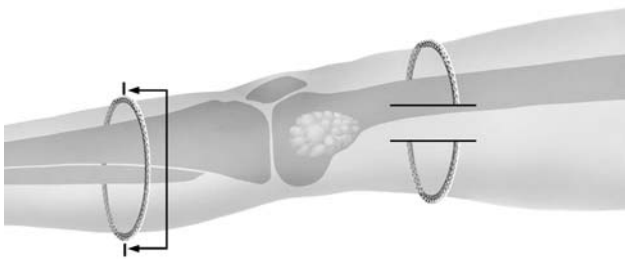

Fig. 1 The incision is planned by measuring the circumference of the distal incision by a sterile cord. This then is used to map to the proximal incision by cutting the cord into two equally sized parts, which are placed in a symmetric fashion at the place where the proximal incision will be made (The proximal incision is shown close to the knee only for illustration purposes).

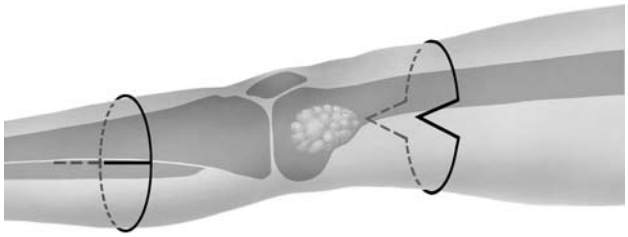

Fig. 2 The distance between the two semicircular incisions is bridged by two symmetric triangular-shaped incisions. Distally, two incisions with the length representing the height of the proximal incision are made.

Fig. 3 The legs of the triangles can be matched exactly, without difficulty, to the needed size.

Case Reports

We have used this incision in eight patients (five females, three males). The average age of the patients at surgery was 25 years (range, 5–70 years). Two patients had a high-grade osteosarcoma, one had a proximal femoral focal deficiency (PFFD), and one had a longitudinal femoral defect. One patient had a diaphyseal femoral defect attributable to osteomyelitis, one had a myxoid liposarcoma (and secondary malignant fibrous histiocytoma subsequent to radiotherapy), one had a high-grade liposarcoma, and one had a leiomyosarcoma, respectively

Table 1. Overview of patients

Patient number	Date of surgery	Followup (months)	Age at surgery (years)	Gender	Disease	Side	Primary or secondary procedure	Oncologic outcome	Range of motion (°)	Weight-bearing	Painless walking	Radiographic signs of plate loosening
1	8/28/01	31	10	F	High-grade osteosarcoma	R	Primary	DOD	90	Full	Yes	None
2	2/10/03	55	13	F	High-grade osteosarcoma	R	Primary	ANED	50	Full	Yes	None
3	1/29/04	53	5	M	Longitudinal femoral defect	L	Secondary		90	Full	Yes	None
4	2/22/07	29	20	M	Myxoid fibrosarcoma/ malignant fibrous histiocytoma	R	Primary	ANED	50	Full	Yes	None
5	1/4/06	37	70	F	Liposarcoma	R	Primary	AWD	90	Full with crutches	Yes	None
6	5/2/05	29	5	F	Proximal focal femoral defect	R	Primary		50	Full	Yes	None
7	5/16/06	34	19	F	Diaphyseal femoral defect after osteomyelitis	R	Primary		90	Full with crutches	Yes	None
8	10/29/ 07	8	61	M	Leiomyosarcoma	R	Primary	ANED	90	Full	Yes	None

DOD = died of disease; ANED = alive with no evidence of disease; AWD = alive with disease.

Fig. 4A–B After having readapted and secured the proximal and distal ends, the proximal soft tissue spindle is fitted properly into the distal part without tension on the wound. (**A**) The intraoperative situation before wound readaptation, and (**B**) after wound closure are shown.

(Table 1). The mean followup was 34.5 months (range, 8–55 months). All wounds healed without skin necrosis at the triangles of the interface of the upper and lower limb. At last followup none of the patients had any sign of infection. One patient died of disease. All others were unrestricted or only slightly restricted in activities of daily living. Two patients participated in exercise and cycling (Table 1). The plate fixation material was left in place in all patients.

A myxoid liposarcoma at the medial vastus muscle in a 16-year-old boy was treated by resection and radiotherapy. Four years later, he had a malignant fibrous histiocytoma of bone develop in the previous radiation field. Resection of

Fig. 5 Two weeks after surgery, the wound had healed uneventfully with the staples still in place.

Fig. 6 The patient was free of infection at 29 months followup.

the distal femur was performed and reconstructed using a tumor endoprosthesis. Because of aseptic loosening, this was replaced by a silver-coated prosthesis. The patient had an infection develop and we removed all hardware. Rotationplasty was chosen as salvage surgery (Fig. 4). The wound healed uneventfully without infection (Fig. 5). The patient was free of infection at 29 months of followup (Fig. 6).

Discussion

We present a new incision technique to facilitate matching the proximal and distal incisions of the leg after rotationplasty. Complications after rotationplasty include wound infection, vascular compromise, nerve palsy, and nonunion with infection being the most severe complication of rotationplasty [12, 14, 19]. Our new incision technique may reduce the risk of soft tissue complications because the soft tissues can be sutured without tension as a result of better fitting of the proximal and distal incisions after resection. Using the rhomboid-shaped incision as originally described, it is often impossible to exactly match the incisions. Specific complications of this incision include harm to soft tissues, wound healing complications, and unfavorable cosmetic results [4, 5, 7, 9, 12]. In addition, this technique requires much experience to perform the correct incisions to perfectly match the circumferences. However, the advantage of the classic incision is that it requires less preoperative and intraoperative planning and is relatively easy to perform. Other conventional incisions described such as the rhombus-shaped skin incision around the thigh and calf as proposed [6, 12] aimed to at least partially eliminate the problem of major discrepancies of the circumferences of the proximal and distal skin borders. However, that incision technique causes difficulties with later skin closure because of the mismatch of the amount of skin of the proximal and distal parts, which is avoided with the technique we present.

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