



ORIGINAL PAPER

DOI: <https://doi.org/10.20883/jms.337>

Skin necrosis after SUPERknee procedure – typical versus modified surgical approach

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ABSTRACT

Introduction. SUPERknee procedure (SK) is a treatment for complex knee instability in children with congenital deformations. Due to wide surgical approach and long time of surgery (ST) the skin around the knee is in risk of ischemic necrosis (SN) or healing complications (HC).

Aim. The purpose of the study is to compare incidence of SN in SK using typical and modified approach.

Material and Methods. Sixteen patients underwent SK since 2015 till 2016, in mean age 8.1 (4.3–12.7) y.o. In 8 cases SK and in 8 SK combined with SUPERhip (SK+SH) was performed. In 6 patients (3 SK and 3 SK+SH) the approach was performed from one incision (OIA). In 10 patients (5 SK and 5 SK+SH) a modified approach was performed, involving additional skin incision (DIA). The occurrence of SN, ST and risk factors of HC were evaluated.

Results. SN appeared in 2 cases treated with OIA (33%). There was no SN in DIA (0%). With this number of patients the difference was below level of significance, $p = 0.1250$, $OR = 11.7$. In one patient treated with SK+SH area of SN was 17.5 cm^2 . In the other patient treated with SK 35 cm^2 . Mean ST in SK was 3.4h (2.5–4.0) and in SK+SH 4.6h (4.0–5.5). ST of the surgery with OIA was 4.1h (2.5–5.5) and in DIA 3.7h (3.0–4.5), $p = 0.4746$. No additional risk factor relevant to SN was found.

Keywords: SUPERknee, SUPERhip, super knee, super hip, healing complications, skin necrosis.

Introduction

Congenital lower limb deficiencies (CLLD) are heterogeneous group of diseases characterizing a wide spectrum of pathology, ranging from mild to severe limb deformations. In this group the most common are: congenital femoral deficiency (CFD), fibular hemimelia (FH) and tibial hemimelia (TH) [1]. Although, in each disease from CLLD the main problem is situated in different localization of the lower limb and requires different ortho-

pedic solutions (eg in CFD the main problem is a hip deformation and in FH the main problems are foot, ankle and cruise deformations), in most cases whole limb is involved with various severity. There are similarities in CLLD and all of them need complex treatment with many stages and many surgical procedures [2–4]. One of the most important common feature in all types of CLLD is the lower limbs length discrepancy of various severity accompanied by wide range of axial deformity [1, 3, 5, 6]. The goal of the treatment of

children born with congenital CLLD is to achieve an optimal function in adult life and as little musculoskeletal pain and complaints, including cosmetic aspects, as possible [7]. It in this purpose normal alignment with equal limb length and a normal gait pattern with full weight-bearing is required [8].

Another typical finding in CLLD is instability of the knee. Depending on the severity of the deficiency, the instability can be detected in early infancy or later during life, sometimes without clinical significance. However, instability can appear during deformity correction and bone-lengthening procedures, leading to flexion contracture or subluxation of the knee and appears to be one of the biggest challenges in deformity correction and lengthening [1, 7]. Prevention of subluxation during lengthening in patients with congenital knee instability can be achieved with bridging of the knee with monolateral or circular fixators. Intensive physical therapy and bracing may prevent knee subluxation during lengthening using intramedullary nails. Knee stability as well as early detection and treatment of knee subluxation have the highest priority in lengthening procedures in all patients with CFD and/or FH [7].

When analyzing the knee deformation in CLLD, not only the stability of the knee must be taken into consideration, but also the patella alignment and the joint contracture [2]. The complex reconstructive procedure for children with significant instability of the knee in course of CLLD called SUPERknee (SK) was introduced by D. Paley [2]. According to Paley SUPER is an acronym for Systematic Utilitarian Procedure for Extremity Reconstruction. This procedure has three goals: reconstruct ACL/PCL, realign patella and correct flexion contracture. In case of CFD may be performed with or independent of the complex hip reconstruction SUPERhip (SH), as well as in FH with distal part of the lower limb reconstruction [3, 5]. In CFD the instability pattern is different than in an isolated tear of ACL and there is more of a rotary instability. Therefore, according to Paley, a purely intra-articular ligament reconstruction is insufficient and can lead to recurrent instability. Thus, the combination of extra- and intra-articular ACL ligament reconstruction is ideal and it can now be safely done as young as 2 years of age [5].

SK is a complex procedure combining two or more of the following five procedures: (1) the Langenskiöld procedure for congenital dislocation of the patella [9]; (2) the MacIntosh procedure for ACL deficiency including extra and intra-articular ACL reconstruction using the fascia lata [10]; (3) the Grammont procedure for recurrent dislocation of the patella [11]; (4) as the reverse MacIntosh to prevent external rotatory instability and to act as an extra-articular posterior cruciate ligament introduced by Paley [10]; and (5) the Paley anterior approach to posterior capsulotomy of knee [2]. The procedure each time is customized and not all steps are needed in each case.

The surgical approach proposed for this surgery was described as a long S-shaped distal to the tibial tuberosity distally and midlateral proximally which can be extension of the SUPERhip surgical approach or performed as isolated incision. It was indicated to perform additional medial incision when capsulotomy is needed [2, 12].

Taking into consideration of benefits of SK procedure we have used it in our Department since 2015 as a preparatory step to the thigh lengthening in children with CLLD. However, when we have used described surgical approach with the single skin incision, in some cases we have revealed skin necrosis at the level of lateral area of the knee. We could not find in the literature a single publication concerning this topic in aspect of SK procedure. Thus, we have analyzed influence of the type of the surgical approach and risk factors affecting the wound healing on the occurrence of the skin necrosis in patients with CLLD.

Material and Methods

All patients treated in our clinic with SK procedure since March 2015 till December 2016 were included into the study. The criterion for the SK procedure was the knee instability due to the congenital limb deficiency (CFD, FH). SK was performed either as a single procedure or in combination with SH procedure. Two types of skin incisions for surgical approach were used: (1) single skin incision surgical approach (OIA) started at the lateral aspect of the thigh and extended laterally around the patella up to the medial part of

the tibial tuberosity (**Figure 1**) or (2) double skin incisions surgical approach (DIA) with additional incision at the medial aspect of the knee served to attach the PCL graft – **Figure 2**.

All patients have been evaluated before surgery, on the first day after surgery the 2, 6, 12

weeks after surgery, 6, 12 and 24 months after surgery. In case of the wound healing problems, the evaluation was performed weekly until the skin healed. The wound healing complications and the incidence of the skin necrosis, the necrosis area, the type of the surgery and the time of

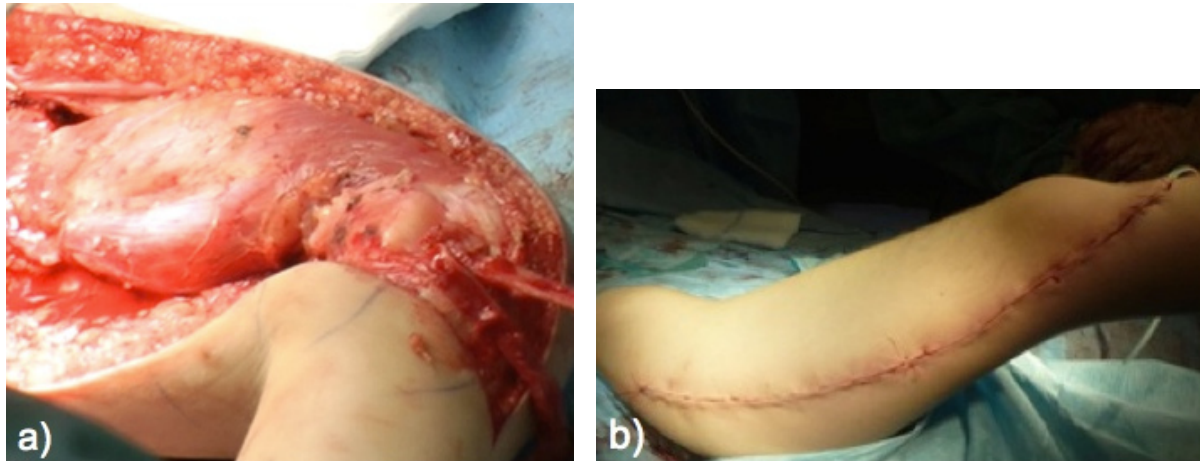


Figure 1. Single incision surgical approach for combination of SUPERhip with SUPERknee surgery, a) during tissues dissection, b) after skin sutured



Figure 2. Double incisions surgical approach for SUPERknee surgery: a) lateral, b) medial

the surgery (ST) were evaluated. From the medical history previously described potential risk factors for the wound healing such as: diabetes, cachexia, immunodeficiency, immunosuppressive therapy, poor nutrition, diverticulosis, infection elsewhere, obesity, smoking, renal failure, hypothyroidism, alcohol abuse and previous surgeries at the area of present treatment were established [13].

Statistical analysis

For each parameter, the mean values, standard deviation and range were calculated. The normal distribution of data was analyzed with the Kruskal-Wallis test. The unpaired t-test was used to compare means between the patients with single vs. double incision surgical approach. The nonparametric parameter distribution was compared using Fisher's exact test. A p-level of 0.05 was considered significant. The data were analyzed using GraphPad InStat statistical software (Graph Pad Software, San Diego, CA, USA).

Results

Sixteen patients were enrolled: 8 boys and 8 girls in the mean age at the time of surgery 8.1 years old (SD \pm 2.6, range: 4.3–12.7). The diagnoses were as follow: 9 patients with CFD, 3 patients with FH and 4 patients with combination of CFD and FH. In 6 patients (3 SK and 3 SK+SH) OIA was performed. In 10 patients (5 SK and 5 SK+SH) DIA was performed. The mean follow-up was 30.2 months (SD \pm 8.1, range (26–41)).

The wound healing problems with the skin necrosis appeared in 2 patients treated with OIA (33%). There was no wound healing problems in DIA (0%), $p = 0.1250$, OR = 11.7 – **Figure 3**.

In both cases the skin necrosis was situated at the anterolateral aspect of the knee. The first patient underwent SK+SH, the area of the skin necrosis after surgery was 17.5 cm². In this case surgery time was 4.5 h. The second patient underwent SK the area of the skin necrosis after surgery was 35 cm². In this case surgery time was 3.5h (**Figure 4**). Both patients healed with the skin scar in 4 months.

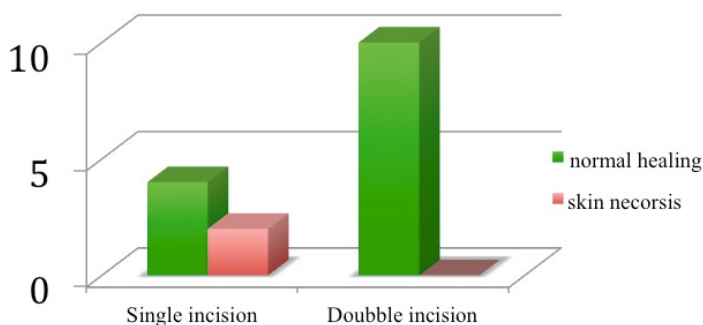


Figure 3. Graph presenting number of the skin necrosis for surgeries performed with single incision surgical approach and double incisions surgical approach

Table 1. The time of the surgery for patients with the skin necrosis and the mean surgery time for all patients

	Surgery time of surgery for the patient with skin necrosis	Mean time of surgery for all patients
SUPERknee procedure	3.5h (n = 1)	3.4h (n = 7)
Combination of SUPERknee with SUPERhip procedure	4.5h (n = 1)	4.6h (n = 7)

Table 2. Number of the patients with the knee surgeries prior to SUPERknee operation

	Prior surgeries at the knee area		No prior surgeries at the knee area	
	Single incision surgical approach	Double inactions surgical approach	Single incision surgical approach	Double inactions surgical approach
Patients with skin necrosis	1	0	1	0
Patients with normal healing wounds	0	3	4	7



Figure 4. Patient treated with single incision surgical approach at 2 week (a), 6 weeks (b) and 12 months (c) after super knee surgery

The mean surgery time was in SK 3.4h (SD \pm 0.6, range: 2.5–4.0) and in SK+SH 4.6h (SD \pm 0.5 range: 4.0–5.5). The surgery time in cases with skin necrosis was similar to the mean surgery time for each group – **Table 1**.

There was no difference in the surgery time between OIA and DIA. The mean surgery time was 4.1h (SD \pm 1.0, range: 2.5–5.5) in OIA and 3.7h (SD \pm 0.6 range: 3.0–4.5) in DIA, $p = 0.4746$.

The prior knee surgeries with the skin scars was present in one patient with skin necrosis (50% of all wound healing problems) when one incision was applied and in 3 patients with normal wound healing, however, all of them have DIA – **Table 2**.

No patient revealed additional disease or risk factor relevant to the wound healing process. No incidence of: diabetes, cachexia, immunodeficiency, immunosuppressive therapy, poor nutrition, diverticulosis, infection elsewhere, obesity, smoking, renal failure, hypothyroidism and alcohol abuse in both groups was noted.

Discussion

The complex method of ACL and PCL reconstruction and improvement stability in CLLD proposed

by Paley is nowadays one of the most promising procedures for children with CFD, FH and TH. This procedure, together with external fixator bridging the knee, allowing the knee motion preservation and accompanied by intensive physiotherapy, provides safe possibility of the femur lengthening with good functional result. Until use this combination, a lengthening of the femur in patents with the knee instability had great burden of the potential risk of knee subluxation [1].

Although, this method is very promising, it is technically demanding and can be associated with severe complications. One of the complications is early wound healing problem. In this method large approach with deep and wide skin dissection is necessary. Even if the surgery is limited only to ACL and PCL reconstruction, without additional steps, the skin and the subcutaneous layer dissection is still very extensive. Such a large approach is needed for a proper graft positioning according to the description of the procedure: there have to be access to posterior capsule, lateral and anterior aspect of the knee as well as medial part of the join up to the intermuscular septum [2]. Especially the PCL attachment to the intermuscular septum at the medial aspect of the knee requires skin dissection from the lateral through the anterior to the medial aspect

of the knee creates large the skin flap, enhance risk of destruction of the skin blood supply and increase chance of the skin necrosis in this area [13, 14].

The early healing problem with skin necrosis may lead to the joint infection and the sever scars at the level of knee joint. Except obvious adverse cosmetic effect and skin sensation disturbance, may cause the knee joint contractures and secondary deformities (**Figure 4**) [13–15]. In our group of patents we deal with the soft tissues very gently. We paid attention to keep the skin flap as thick as possible, we kept the exposed tissues moist, we tried not to pull to hard tissues with retractors and we used a wound drainage. All this means are described as helpful to decrease risk of skin necrosis [13]. Nevertheless, we have observed two cases of the sever wound healing problem. Thus, when we evaluated our previous cases we observed that patients who needed additional medial incisions due to capsulotomy or 8-plate implantation have better wound healing. The second medial incision allows us to attach properly PCL graft to the intramuscular septum and decrease skin flap dissection at the antero-medial aspect of the knee. According the studies concerning the wound healing, careful attention should be paid to limiting the size of skin flaps and keeping them thick to preserve the skin blood supply [13, 14]. The blood supply to the skin over the knee joint is fasciocutaneous and is more robust on the medial side [16] and additional small medial incision may reduce devascularization of the skin flap. We are aware that with this number of patients the difference was below level of statistical significance, $p = 0.1250$, however, due to severity of this complication we perform all SK surgeries with the additional medial skin incision and we do not have new cases of wound healing problem.

Another issue which is associated with the wound healing problems is prolonged time of the surgery [13], however the surgery time in cases with skin necrosis was similar to mean time of each type of surgery in our group (**Table 1**).

In search of the additional risk of the wound healing complication, due to paucity of literature concerning SK procedure, we based our possible risk factors on the literature concerning the

wound healing problem after total knee arthroplasty (TKA). It was motivated by similar area of the surgery and great number of publications concerning the surgical approach complication in TKA [13, 14]. Unfortunately, most of the risk factors are not suitable for the pediatric patients (eg alcohol abuse or smoking) another are rare in this group (eg diverticulosis or hypothyroidism). Thus, probably this was the reason why we could not find many of them in our study.

Another important risk factor in the wound healing problems are skin scars after previous surgeries at the knee area [13, 14]. In our study the number of patients is too small to demonstrate statistically significant difference, however in our group prior surgeries in single incision approach were had greater impact than in double incision approach.

The wound healing problem was not mentioned by the author of the procedure. However in early technique description the additional medial incision was suggested when the knee posterior capsulotomy is needed [2, 12]. Whereas, in the most recent publication there is suggestion that, if performed with a SH procedure, the incision is a distal extension of the SH incision. If performed as an isolated procedure, it can be done through one midline anterior incision or one medial and one lateral incision [5]. In our opinion the second incision is beneficial and can be used in each case of SK for PCL graft placement.

The strong site of this study is the fact that this is a first study concerning this problem. The SK procedure address important problem of the knee instability in patients with CLLD. The popularity of this technique increases and more surgeons use it in practice. Thus, the study may help other surgeons avoiding significant complications with wound healing in SK procedure.

One of the limitations of this study is small sample size, however, these procedures are not routinely performed surgeries. On the one hand further evaluation with the larger sample size could give some additional results, on the other it is ethically controversial to use the single incision approach when the risk of the skin necrosis is known. Another limitation is that is single center study. It would be beneficial to compare our observations with patients from other hospitals.

Conclusions

The double skin incision surgical approach for the SUPERknee procedure may decrease incidence of the wound healing complications and the skin necrosis. It does not extend the time of surgery. It should be considered in all cases, especially in patients with previous surgeries in the knee area and with additional risk factors.

Acknowledgements

Conflict of interest statement

The authors declare no conflict of interest.

Funding sources

There are no sources of funding to declare.

Abbreviations: CLLD, congenital lower limb deficiency; CFD, congenital femoral deficiency; FH, fibular hemimelia; TH, tibial hemimelia; SUPER, Systematic Utilitarian Procedure for Extremity Reconstruction; SK, SUPERknee; SH, SUPERhip; OIA, single incision surgical approach; DIA, double skin incisions surgical approach; ST, time of the surgery.

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Acceptance for editing: 2019-05-09
Acceptance for publication: 2019-06-29

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