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Original Article

Patient satisfaction in fast-track limb lengthening and realignment surgery

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ABSTRACT

INTRODUCTION. We investigated whether an accelerated protocol could reduce length of stay (LOS) in reconstructive orthopaedic surgery. Procedures included limb lengthening, limb alignment corrections and hardware removals. Patient satisfaction was evaluated using patient-reported outcome measures (PROMs). Possible cost savings were estimated.

METHODS. A total of 26 patients scheduled for 34 elective procedures were included, comprising intramedullary limb lengthening (n = 6), osteotomies (n = 13) and hardware removals (n = 15). Outcomes included LOS, short-term complications and PROMs-based satisfaction. LOS was compared with LOS in a historic cohort (n = 11).

RESULTS. Same-day discharge was achieved in 19 of 22 planned cases (87%). Eight of 12 cases (67%) planned for discharge on the day after surgery achieved the goal. Seven cases required 1-4 unplanned nights of hospitalisation, four following plating osteotomies, one external ring fixation, one motorised intramedullary limb lengthening implementation and one hardware removal. Reasons for delayed discharge included pain (n = 5), desaturation (n = 1) and anticoagulant issues (n = 1). Average LOS was 1.1 days compared with 4.4 days in the historic cohort. PROMs indicated high satisfaction, with 16 of 22 patients reporting an excellent or very good overall experience. Direct cost savings were approximately 1,000 euros per night saved.

CONCLUSIONS. Fast-track protocols in reconstructive surgery can substantially reduce LOS and are associated with high patient satisfaction. Patients with pre-existing pain issues or patients undergoing tibial procedures may require additional support.

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Increasing pressure on limited healthcare resources has driven the development of fast-track surgical solutions, occasionally referred to as enhanced recovery after surgery (ERAS) and same-day discharge (SDD), while maintaining high patient satisfaction. Yet reconstructive limb lengthening and corrective alignment surgery are traditionally considered burdensome, painful and opioid-demanding, and the field is only scarcely reported in the literature.

However, modern, percutaneous, minimally invasive techniques and weight-tolerant implants result in acceptable pain levels, enabling early mobilisation and discharge, suggesting that the limitations may be overstated.

We investigated whether an accelerated protocol could reduce length of stay (LOS) following reconstructive limb surgery [1, 2]. Patient satisfaction was evaluated using patient-reported outcome measures (PROMs) [3, 4].

Procedures included motorised intramedullary limb lengthening (MILN), alignment osteotomies – high tibial osteotomy (HTO), distal femoral osteotomy (DFO), and derotations – using internal fixation with plates or nails and related hardware removals.

Methods

A total of 26 patients (mean age 42 years (range: 21-64 years), eight females, 18 males) scheduled for 34 elective procedures between January 2021 and November 2024 were included: intramedullary limb lengthening (n = 6), osteotomies (n = 13) and hardware removals (n = 15), including combined surgery on two or more segments (n = 3). Six patients underwent repeated procedures (2-3 surgeries), typically implantation followed by explantation.

Eligible patients were aged 18-70 years with an American Society of Anesthesiologists (ASA) score ≤ 2. Patients with disabling comorbidities, psychiatric disorders or without home support were excluded.

The protocol aimed at same-day (before 20:00 hours) or next-day discharge, ideally increasing patient flow, reducing costs and shortening return-to-work time. The protocol involved all caregivers (surgeons, anaesthesiologists, nurses, physiotherapists and relatives) and consisted of pre-, peri- and post-operative components, as summarised in **Table 1**.

TABLE 1 The patient protocol.

Time	Description
Preoperatively	Patients were encouraged to perform muscle-strengthening "prehabilitation" exercises to improve outcomes Patients and relatives received structured information and were actively involved in planning post-operative care and early discharge
Perioperatively	Minimally invasive surgical techniques: percutaneous osteotomies, small-incision nailing and plating, avoiding epidurals and other motor blocks Tranexamic acid administered, and compression tourniquets used to reduce bleeding
Post-operatively	Compression bandages, cooling devices and local infiltration and intra-articular anaesthesia with vasoconstrictors, as relevant, were applied to reduce bleeding, and patients were encouraged to weight-bear as tolerated Upon discharge, patients were contacted within 24 h and were provided with a 24/7 contact number for acute concerns, e.g. bleeding or pain All discharge elements were provided and checked: letter of discharge, guidelines, analgesics, supplementary dressing, etc.

The primary outcome was LOS, compared with a historic cohort of 11 corresponding procedures (eight MILN implementations, one derotation nail implantation, two explantations) performed prior (2016-2019) to the implementation of the fast-track protocol. Secondary outcomes included short-term complications (occurring < 1 week after surgery) and patient satisfaction, assessed using PROMs collected via email as a simplified version of the Danish "LUP" questionnaire [5] (see Appendix), administered through Google Forms (a web-based survey tool.

Complications were defined as events leading to one or more unplanned nights at the hospital or re-contact with the department, typically due to bleeding through bandages. Long-term complications (e.g., embolism, infection, contracture, regenerate insufficiency, implant-related problems or malfunction: breakage or corrosion) were not assessed in this study [6, 7]. Estimated average costs were calculated by diagnosis-related

group (DRG) tariffs and internal data on typical total costs from the Department of Hospital Finance at a larger university hospital (Odense University Hospital, personal communication) and related cost studies from our institution [8]. Late-start surgery (after 17:00 hrs) causing additional nights at the hospital was not counted as a delay (n = 1). The protocol's development drew inspiration from fellowships in elective limb-lengthening units in Europe (Germany, Italy) and the USA, e.g. same-day surgery, pre-training, post-operative physiotherapy and mobilisation, and anesthesiology aspects from arthroplasty protocols (avoiding motor blocks to facilitate mobilisation) [9].

Patients provided written informed consent to participate in the study and to the acquisition of their electronic patient record data.

Trial registration: study permission: R-24053042 rh dk.

Results

Table 1: Length of stay (LOS: 19 of the 22 patients (87%) who were planned for SDD achieved the goal **(Table 2**). Furthermore, 8 of 12 (67%) patients planned for discharge the day after surgery achieved the goal. Seven procedures required 1-4 unplanned nights of hospitalisation. Among these, five were osteotomies around the knee, one was a hardware removal and one was a MILN. Fourteen of 15 hardware removals planned for same-day surgery were discharged as planned. This included four patients with combined procedures; one patient had two MILNs and one plate removed, and another had four plates around the knee removed. One patient needed an additional night due to a late start and oxygen desaturation. The average LOS was 1.1 days compared with 4.4 days in the historic cohort of 11 procedures. Three patients had combined implementations and explantations in a single surgery. No patients required re-operations or later readmissions. All patients walked independently, with or without crutches, at discharge.

TABLE 2 Patient characteristics.

Procedure no.	Patient ID	Diagnosis	Surgery	Segment	Planned LOS (d)	Real LOS	Complications	Pain history	Satisfaction
Elective procedures									
1	A	Achondroplasia	MILN implantation	Femur	1.0	5.0	Pain	×	Poor
2	A	Achondroplasia	MILN implantation	Femur	1.0	1.0			
3	B	Posttraumatic	MILN implantation, explantation: plate	Femur	1.0	1.0		×	Excellent
4	B	Posttraumatic	MILN implantation, explantation: plate	Femur	0.5	0.5			
5	C	Achondroplasia	ERF: lengthening	Tibia	1.0	2.0	Anticoagulant issue		Very good
6	D	Posttraumatic	MILN implantation + plate	Femur	1.0	1.0			
7	D	Posttraumatic	Osteotomy, percutaneous	Femur	0.5	0.5			
8	E	Posttraumatic	HTO	Tibia	1.0	5.0	Pain		Satisfactory
9	F	Cerebral palsy	MILN implantation	Femur	1.0	1.0			Very good
10	F	Cerebral palsy	MILN explantation	Femur	0.5	0.5			
11	G	Congenital anisomeli: PFFD	MILN implantation	Femur	1.0	1.0			Very good
12	G	Congenital anisomeli: PFFD	MILN explantation	Femur	0.5	1.0	Late surgery start, desaturation		
13	H	Posttraumatic	Retrograde nail	Femur	0.5	0.5			Very good
14	I	Posttraumatic	DFO: plate	Femur	0.5	1.0	Pain, bleeding	×	
15	J	Posttraumatic	DFO: plate	Femur	1.0	1.0			
16	K	Rachitis	HTO: plate	Tibia	1.0	2.0	Pain		Excellent
17	L	Rachitis	DFO: plate	Femur	1.0	4.0	Pain	×	Fair
18	M	Posttraumatic	Explantation tibial nail	Tibia	0.5	0.5			Very good
19	N	Osteosarcoma	ERF application	Tibia	0.5	0.5			Excellent
20	O	Posttraumatic	Fitbone explantation	Femur	0.5	0.5			Very good
21	P	Rachitis	4-plate explantation around knee	Femur + tibia	0.5	0.5			
22	Q	Posttraumatic	Explantation BTN	Femur	0.5	0.5	Disintegration of implant		
23	R	Posttraumatic	Explantation tibial nail	Tibia	0.5	0.5	Bleeding		Fair
24	S	Osteosarcoma	Exchange nailing, brisément	Femur	0.5	0.5			Excellent
25	T	Congenital malformation	DFO,variazation and derotation: nail	Femur	0.5	1.0	Pain	×	Excellent
26	T	Congenital malformation	DFO, variazation and derotation	Femur	0.5	0.5			
27	U	Posttraumatic	DFO, variazation	Femur	0.5	0.5			Fair
28	V	Posttraumatic	Open tibial fracture: ERF	Tibia	0.5	0.5			Very good
29	W	Leri-Weils syndrome	Explantation: fitbone	Femur	0.5	1.0	Late surgery start: 17 hrs		Very good
30	A	Achondroplasia	Explantation MILN bilateral	Femur	0.5	0.5		×	
31	N	Osteosarcoma	Explantation ERF	Tibia	0.5	0.5			
32	X	Posttraumatic	Explantation MILN	Tibia	0.5	0.5			Excellent
33	Y	Posttraumatic	Explantation MILN	Femur	0.5	0.5			Excellent
34	Z	Neonatal sepsis, bifocal:	Explantation: 2 × MILN + 1 × plate	Femur + humerus	0.5	0.5	Bleeding: recontact		Excellent
Average						1.1			
Historic cohorts									
1	A	Congenital: malrotation	Bilateral nail implantation: derotation	Femur		7.0			
2	A	Congenital: malrotation	Bilateral nail explantation	Femur		3.0			
3	B	Posttraumatic	MILN implantation, explantation plate	Femur		5.0			
4	C	Posttraumatic	MILN implantation	Femur		7.0			
5	D	Posttraumatic	MILN implantation	Femur		5.0			
6	D	Posttraumatic	MILN explantation	Femur		2.0			
7	E	Léri-Weill syndrome	MILN implantation	Femur		3.0			
8	F	Posttraumatic	MILN implantation	Femur		3.0			
9	G	Neonatal sepsis:	MILN implantation	Femur		3.0			
10	H	Posttraumatic	MILN implantation	Femur		5.0			
11	I	Posttraumatic	MILN implantation	Femur		5.0			
Average						4.4			

BTN = bone transport nail; DFO = distal femoral osteotomy; ERF = external ring fixator; HTO = high tibial osteotomy; LOS = length of stay; MILN = motorised intramedullary lenghtening nail; PFFD = proximal femoral focal dysplasia.

All five patients who underwent identical bilateral procedures did better and faster on their second surgery, suggesting a positive learning curve as both staff and patients became familiar with the setup. When comparing femoral MILN lengthenings exclusively between cohorts, results were similar, reducing LOS from four to one day.

Complications

Reasons for delay were pain (n = 5), anticoagulant treatment issues (n = 1) and desaturation (n = 1). Four of the five patients with pain-related prolonged LOS had previous issues with pain management. Three patients had bleeding through their dressings, requiring exchange. One device disintegrated at explantation (a bone transport

nail), but did not cause delayed discharge. The estimated direct cost reduction was approx. 1,000 euros per night saved. When focusing strictly on reimbursement (DRG), the saving was approx. 300 euros per night.

PROMs: 22 of 26 patients completed the PROMs questionnaire. The overall experience was rated as excellent (n = 8), very good (n = 8), satisfactory (n = 2), reasonable (n = 3) or poor (n = 1). Thus, most patients rated their experience positively, with 16 of 22 (73%) reporting an excellent or very good overall experience. Of those (n = 5) reporting moderate satisfaction, all felt unprepared for discharge on the day of surgery. The response rate was 85%.

Discussion

Patient-reported outcomes indicated a generally high satisfaction, although a subset of patients required additional post-operative support. Our results on LOS are in agreement with the results of a comparable series on same-day surgery by Dubin et al. [10] who evaluated femoral lengthenings (19 of 20 cases) in a dedicated outpatient context.

Studies from arthroplasty and spine surgery have demonstrated even shorter hospital stays and higher throughput [11-13], although these results may not be directly comparable because of differences in patient populations, surgical indications and perioperative pathways.

However, evaluating patient satisfaction from the perspective of this study is limited by the lack of data on the satisfaction rate of patients who underwent conventional, longer hospital stays.

Moreover, traditional satisfaction rates in elective orthopaedic surgery are estimated to be 85% or higher [14], whereas our satisfaction rate was 73%. However, satisfaction rates in, e.g. arthroplasties, could be higher, since our indications, expectations and patient characteristics differ from those of the general orthopaedic cohort: patients are younger and have a high functional level. The indications are often long-term (prevention of degenerative disease, low-back pain, cosmesis, etc.), whereas the indication for most other elective orthopaedic procedures is pain and/or declining function. Such surgeries can produce almost immediate relief. This is not the case with our procedures, which may take months to achieve (e.g. healing of osteotomy and/or regenerate healing after completion of the lengthening procedure, etc.).

Four in five patients who reported pain that caused delays had previous pain issues and/or frequent opioid use, raising the question whether such patients may not be suitable for elective orthopaedic surgery [15] or may require specific preparation. Limb lengthening as a field is not without complications; up to 50% of patients experience some degree of complication during their treatment course, including: regenerate insufficiency, articular stiffness, and, more rarely, hardware failures, corrosion, breakage, screw back-out, explantation problems, etc. [6, 7]. These complications mostly arise at a later stage as a consequence of distraction osteogenesis and lengthening, rather than the primary procedure, which is minimally invasive and mostly performed percutaneously.

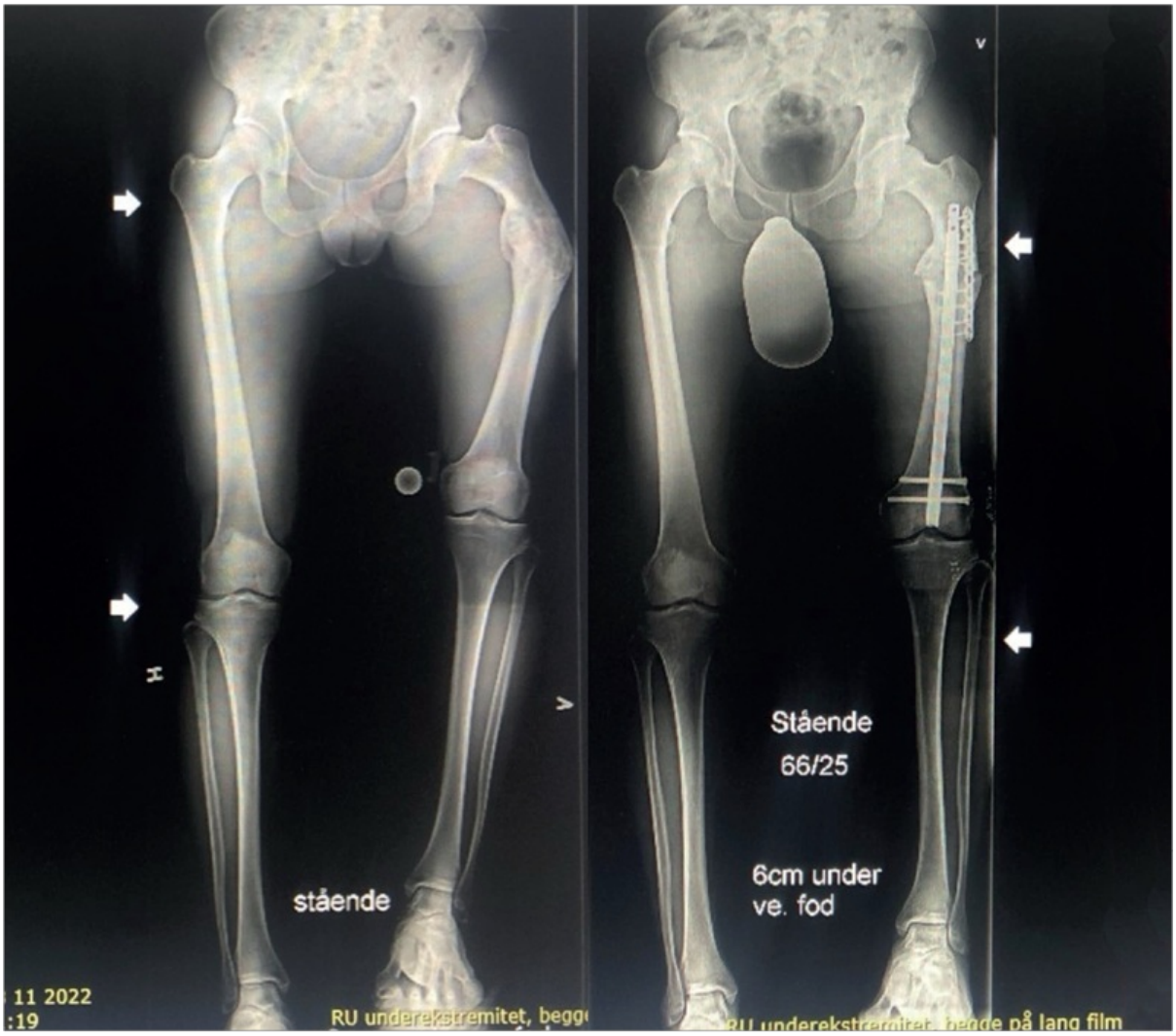
The reduction in LOS may translate into both direct and indirect benefits. While the estimated direct cost savings per night are mixed, the primary advantage likely lies in increased bed availability and improved patient flow.

Evidence for prehabilitation is modest and largely lacking in reconstructive procedures. Its relevance in this patient population – typically young and fit – remains uncertain and may be limited, as suggested by recent systematic reviews and meta-analyses [16, 17].

Further studies should investigate tibial problems, include the return-to-work factor, and comprise an in-depth analysis of possible associated economic benefits, e.g. reduced absenteeism and fewer nosocomial infections

[18]. Tibial lengthening has been associated with higher complication rates than femoral lengthening in several studies [6, 19, 20], making the femur the preferred segment to lengthen, whenever possible (**Figure 1**). This is probably the reason why most cosmetic lengthenings are femoral – though this approach may result in a mildly disproportionate appearance. Our sample size in tibias did not allow for an analysis of this aspect.

FIGURE 1 Patient D. First procedure: an osteotomy fixed with plate and combined retrograde motorised intramedullary limb lengthening nail, discharged as planned on the first post-operative day. Secondary procedure: osteotomy, the patient was disharged on the day of surgery (before 20 hrs). Reprinted with permission.



Limitations

Our study was limited by the small number of participants, the heterogeneity of the procedures and the retrospective nature of the control cohort, which was not fully matched between groups. Cost savings in LOS in an SDD setting are difficult to compare, as no clear consensus on methodology exists [8], and numbers will vary markedly across institutions and healthcare systems.

Conclusions

Intramedullary femoral limb lengthening and corrective osteotomies are feasible in a same-day or next-day discharge setting. Compared with a historical cohort in femoral MILN, average LOS was reduced from four to one, demonstrating that long hospitalisations in corrective orthopaedic surgery may, to some degree, be a cultural phenomenon.

Hardware removals, including multiple nail and plate removals, were uniformly performed with discharge on the day of surgery.

While most patients benefited from the protocol, a subgroup undergoing plating osteotomies around the knee and tibial procedures required additional care. Patients with previous pain issues may require additional preparation. Bleeding through dressings and pain were the most frequent complications.

The findings of this study are limited to LOS. Larger studies should investigate a broader picture of advantages and savings. For such studies, the following are mandated: Meticulous planning of all details in the flow, pain and haemostasis management, careful patient selection, an overnight backup in cases of delay and persistent pain, flexibility, close follow-up and involvement of all allied healthcare providers and relatives.

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AI was used for reference formatting and consistency checks. AI was not used for writing

Supplementary material **a01260013-supplementary.pdf**

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