

The value of thermography in evaluating the effectiveness of early rehabilitation following multiple knee replacement surgeries: A Case Study

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Abstract:

Pathological conditions involving ongoing inflammatory processes produce heat signatures in the affected areas of the body; infrared thermography can detect these changes and serve as a useful screening tool. **The aim of this study** was to assess skin temperature at the site of the postoperative scar following knee replacement to better understand patient's physiological status during physiotherapy in early rehabilitation. The main research hypothesis was that excessive increases in skin temperature around the postoperative scar following joint replacement surgery may indicate an abnormal early rehabilitation process, highlight the need for follow-up assessments to determine whether joint degeneration was adequately addressed, and potentially signal the necessity for revision surgery. **Data and Methods.** The present study analysed changes in skin temperature of the anterior surface of the knee joint in the area of the postoperative scar in a man aged 70 years. The subject patient had two surgical procedures on the knee joint. After the first left knee replacement, the patient was admitted to the rehabilitation ward for two weeks. Five months after the first procedure, a revision surgical procedure, namely the total knee replacement (TKR) with resurfacing of the patella and removal of patellar adhesion masses, was performed. **Results.** In the case of changes in skin temperature observed in the subject patient during the course of the early rehabilitation (1–3 weeks after the first surgical procedure) increases in skin temperature levels were greater and more persistent increases than is considered normal. A temperature increase of even more than 4°C two weeks after the first surgery might indicate the need for revision surgery. **Conclusion.** Skin temperature monitoring can be a useful additional tool for the early detection of inflammatory congestion, especially when used in combination with other clinical indicators and imaging procedures.

Key Words: infrared thermography – gonarthrosis – cryotherapy – magnetotherapy

Introduction

For years, infrared thermography has been widely used in diagnosing pathological conditions associated with changes in the degree of blood supply to the examined area and resulting from reactive physiological or inflammatory hyperaemia in medical conditions (Scheidt S. et al., 2020; Schiavon, G. et al., 2021). Pathological states with ongoing inflammatory processes result in specific heat signatures in affected parts of the body; infrared thermography (IRT) detects these changes and can be used for screening (Kumar P. et al., 2024).

Modern devices are advanced and their non-contact, convenient and precise readings can be helpful in many subfields of medicine. Orthopaedics, as a broad field of medicine, has been using this technology for a variety of indications, and this review of the scope of those indications was conducted to evaluate these already established indications and possibly extend its application options, especially in orthopaedics and rehabilitation following orthopaedic surgeries (Fernandes, A. D. A. et al, 2018; Radziejowska M. et al., 2020a; Radziejowska M. et al., 2020b; Castonguay T. & Dover G., 2023; Radziejowska M. et al., 2023; Damayanti, R. et al., 2024; Sugiyanton F. et al., 2024). A study by L. De Marziani et al. (2023) showed that the temperature of knees affected by degenerative changes depended on the degree of joint degeneration and symptoms: patients with a higher degree of gonarthrosis in symptomatic knees presented higher temperatures of total knees, as well as lateral and medial patella areas, in comparison to asymptomatic knees, (L. De Marziani et al., 2023).

Peri-prosthetic joint infections accompanied by elevated skin temperatures around the knee is associated with infections (Zeng Y. et al., 2016; Izakovicova, P. Et al.; 2018) and in such cases thermography is commonly used by clinicians as an additional mean of assessing patient's condition, including the possibility of peri-prosthetic joint infection – PJI (Watts A. T. et al., 2024). At the same time, it is well known that distribution of surface skin temperature after uncomplicated total knee replacement procedure also shows variability, which is thought to be related to the healing process and partly to the heat generated by the prosthesis, which typically has metal components (Gavish L. et al., 2023; Watts A. T. et al., 2024). In cases of extensive degenerative changes of bone tissue within the patella, a single knee replacement procedure may not be sufficient. This

situation may occur as a result of concomitant degenerative changes to the patella which requires a patellar resurfacing procedure along with removal of the extensive adhesive lesions (Parsons T. et al., 2021).

The aim of the study was to determine the temperature of the skin at the site of the postoperative scar following knee replacement in order to clarify patient's condition during physiotherapy treatment in the process of early rehabilitation. The main research hypothesis was that excessive skin temperature elevations in the area of the postoperative scar after joint replacement surgery may indicate an abnormal course of the early rehabilitation period after surgery, the need for follow-up examinations to assess if the degeneration in the area of the knee joint was properly eliminated and for a revision surgery.

Material & methods

Participants

The present study analysed changes in skin temperature of the anterior surface of the knee joint in the area of the postoperative scar in a man aged 70 years (body weight – 108 kg, height – 1,80 m, BMI – 33,34 kg/m²). The study analysed patient's condition after the left knee replacement procedure. The surgical procedure was recommended and performed due to a diagnosis of osteoarthritis of the left knee joint. In addition, the patient was diagnosed with gonarthrosis of both knee joints (primary bilateral, ICD-10 code M17) and a hypertension as a comorbidity.

The subject patient underwent two surgical procedures on the knee joint. The first left knee replacement was carried out on 5 February 2025. The patient was admitted to the rehabilitation ward on 14 February 2025 and stayed there until 7 March 2025. On 2 July 2025, the second surgical procedure was carried out, i.e. the revision total knee replacement (TKR) with resurfacing of the patella and removal of patellar adhesion masses.

Procedure

Thermographic examinations were performed before and after the first knee replacement procedure, and during the 2-week rehabilitation hospitalisation. During the hospitalisation, physiotherapy treatments were performed daily in the following order: Biopteron lamp therapy; segmental massage of the lumbosacral spine; isometric, self-assisted and non-weight bearing exercises in a kinesiotherapy room; targeted liquid nitrogen cryotherapy; magnetic therapy with a static low-frequency magnetic field.

Thermography procedures were also carried out before and after the second surgical procedure, and the subject patient's medical records from 2 February to 5 July 2025 were analysed.

Instruments

Thermograms were taken with a FLIR-6 thermographic camera (Tallinn, Estonia). Thermograms of the left knee joint (the operated one) were taken in the medial area of the patella, as this is where the postoperative scar was located. In some cases, images of the non-surgical right knee were taken in order to compare skin temperatures in the anterior portion of the knees. The thermograms were analysed using FLIR Tools software (Tallinn, Estonia). When measuring skin temperature, the thermographic camera was positioned at a distance of 1 m with general parameters set to: emissivity – 0.6; reflected temperature – 34.0°C.

Results

After the first knee replacement surgery, an increase in skin temperature was observed in the postoperative scar area (Fig. 1). The increase in skin temperature in the postoperative scar area was 2.4 °C in comparison to the unoperated knee; and 3.6 °C in comparison to the corresponding parameter measured before the surgery (see Fig. 1).

Measurements of skin temperature in the postoperative scar area during the 14-day rehabilitation hospitalisation, that started seven days after the surgery, showed that this parameter stayed elevated throughout the period of hospitalisation (Table 1). Measurements taken on the last day of hospitalisation showed mean, maximum and minimum skin surface temperatures slightly higher than at the start of rehabilitation. Undoubtedly, such values themselves should not be considered alarming. Literature data show that temperature increase after a joint replacement surgery of no more than 3.42 °C during a six-month postoperative period is normal and only higher levels of temperature increase together with clinical symptoms such as pain and swelling in the area of the postoperative scar must be considered concerning (Jesry, F. et al., 2025).

Additionally, results of the analysis of how individual physiotherapy treatments changed skin surface temperatures in the postoperative scar area turned out to be interesting. After the magnetotherapy treatment utilising a static low frequency magnetic field, the mean temperature of the examined area decreased by 2.2 °C (Fig. 2). It should be noted that during the rehabilitation period some physiotherapeutic procedures induced opposite temperature responses. For instance, the Biopteron lamp treatment could have raised the skin temperature in the scar area maximally up to 40 °C (mean for the area – 36.7 °C, and minimum – 33 °C). In contrast, during the procedure of targeted cryotherapy, the skin temperature decreased to a minimum of 20.6 °C (mean for the area – 25.7 °C; maximum – 29.1 °C). Patient's medical records noted that after the knee replacement surgery, the flexion angle was 85°. The patient was discharged from the rehabilitation hospital in good general condition, however, there was a significant reduction in the flexion angle of the operated knee to 76°. Subjectively, the patient felt pain in the operated knee sometimes to a degree that made sleeping through the night impossible and swelling of the knee while the thermography showed an increase in the temperature of the

inguinal lymph node area to the maximum of 40.1 °C. However, blood level of the C-reactive protein did not show a deviation from its normal levels (4.54 mg/L; with a norm of < 5.50 mg/L). Imaging conducted after the rehabilitation hospitalisation enabled identification of the cause of patient's poor condition and the presence of unsatisfactory clinical symptoms in the joint area (Fig. 3).

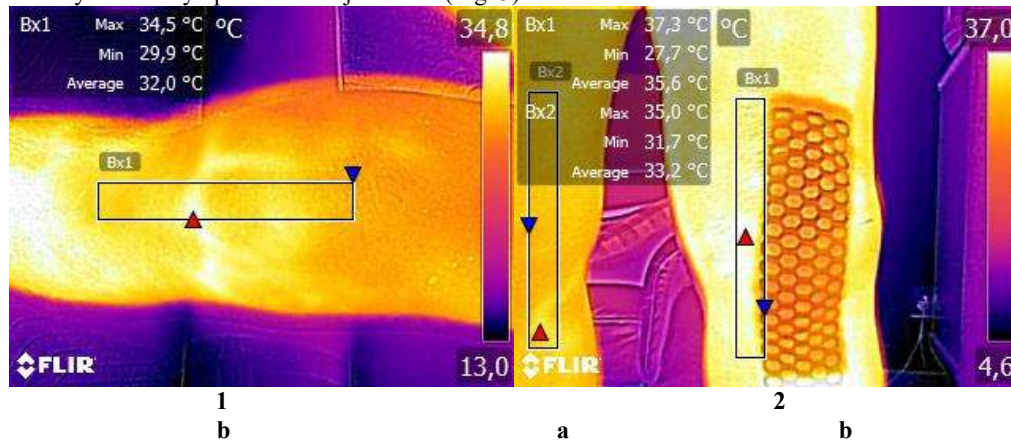


Fig. 1. Preoperative skin temperature of the operated knee (1) and postoperative skin temperature in the postoperative scar area (2): where (a) – the right, unoperated knee; (b) – the left, operated knee.

The second surgical procedure was performed 5 months after the first one and was aimed at eliminating the knee joint adhesions after the total knee replacement with patellar pain syndrome. The surgery included resurfacing of the patella and removal of adhesion masses around it. Thermography showed that the skin temperature in the postoperative scar area decreased very quickly and 2 weeks after the surgery it was no different to that recorded on the unoperated knee (Table 2). By the third day of hospitalisation after the second surgery, the flexion angle had improved to 116°.

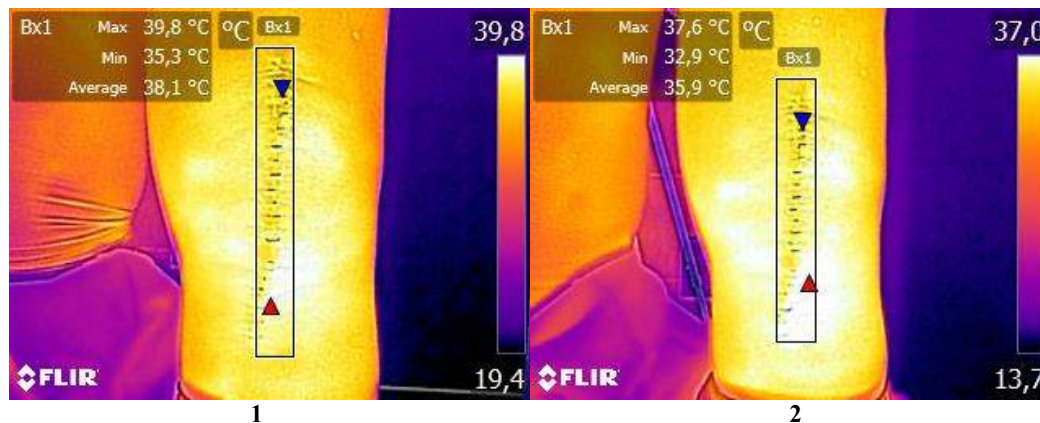


Fig. 2. Skin temperature before (1) and after (2) the first magnetotherapy treatment conducted in the rehabilitation hospital during the early rehabilitation period after the left knee replacement surgery.

Discussion

Temperatures of knees affected by degenerative changes depends on the degree of joint degeneration and the presence of symptoms, with higher temperatures occurring in symptomatic joints, particularly in cases of common lateral knee pain and more severe gonarthrosis. Symptomatic knees show a different pattern compared to asymptomatic knees, with the greatest temperature changes occurring in the medial region (L. De Marziani et al., 2024).

A systematic review by Jesra, F. et al. (2025) highlights differences between normal and abnormal skin temperature elevations in the postoperative scar area after a joint replacement surgery. Normally, skin temperature in the operated joint after the total knee replacement shows steady increase (ΔST), peaking in the first week after the surgery and gradually returning to the baseline over 6–12 months. In cases with no complications, the temperature increase averages at 3.42 °C and decreases in a predictable manner, reflecting the physiological trajectory of inflammation and healing. In the case of skin temperature changes that occurred in the subject patient during the period of early rehabilitation (1–3 weeks after the surgery), higher and more sustained increases in skin temperature levels were observed. A temperature increase of even more than 4 °C two weeks after the initial surgery may indicate the need for a revision surgery. Obviously, the increase in skin temperature in the surgical area alone cannot be considered the sole and reliable criterion in this situation. The most recent

common criteria developed by the European Bone and Joint Infection Society (EBJIS) do not include skin temperature as such criterion, but only the following clinical signs: recent fevers, purulent discharge and a sinus tract communicating with the joint (Matla, J. et. al., 2017; McNally M. et al., 2021). Other criteria are largely based on imaging methods (e.g. X-ray signs of loosening) or laboratory tests (e.g. serum CRP, serum leukocyte count and aspiration culture with Gram staining) (McNally M. et al., 2021). However, there is no doubt that thermography in combination with such clinical signs and symptoms as pain and lack of progress in improving the range of motion in the operated joint may be used as an additional diagnostic method of determination of the correctness of the rehabilitation process. This might initiate the use of imaging diagnostic methods to determine the cause of the temperature elevation and to decide on the next surgical procedure.

Table 1. Skin temperature changes in the operated joint (the postoperative scar area) after the first surgery during the 14-day rehabilitation hospitalisation, where: 1 – before; 2 – and after a physiotherapeutic procedure.

No.	Skin temperature, (°C)	Bioptron lamp		LS spine massage		Exercises		Cryotherapy		Magnetotherapy		Exercises	
		1	2	1	2	1	2	1	2	1	2	1	2
1	Tmax	37.3								39.8	37.6		38.9
	T min	28.7								35.3	32.9		33.3
	Average	34.5								38.1	35.9		37.3
2	Tmax	38.9	37.3				39.2		34.2	37.9	37.4		40.2
	T min	33.4	33.4				36.0		25.8	33.3	33.5		34.4
	Average	36.8	35.7				37.7		29.5	36.4	36.2		38.5
3	Tmax	38.7			39.7		39.9		34.6				
	T min	34.7			35.7		36.6		24.4				
	Average	37.5			38.0		38.4		29.0				
4	Tmax					39.9	37.5		35.3		38.0		36.4
	T min					36.0	35.6		28.1		36.3		34.6
	Average					38.2	36.4		31.4		37.3		35.5
5	Tmax	37.0					37.3		34.1	37.4	37.4		36.6
	T min	35.3					34.9		31.8	36.3	33.4		34.6
	Average	36.1					36.0		33.3	37.0	36.1		35.3
6	Tmax	35.0					37.1						
	T min	32.1					35.2						
	Average	33.3					36.2						
7	Tmax	37.7											
	T min	36.0											
	Average	36.8											
8	Tmax	37.4											
	T min	36.2											
	Average	36.8											
9	Tmax	37.7					38.4		34.4				
	T min	35.6					36.6		25.5				
	Average	36.8					37.4		29.9				
10	Tmax		39.3		38.1		38.7		35.7				
	T min		33.8		35.2		36.4		31.5				
	Average		38.0		37.1		37.4		33.9				
11	Tmax		39.2				36.2		29.6				
	T min		36.5				33.4		22.6				
	Average		37.9				35.0		26.0				
12	Tmax		38.1				38.5						
	T min		35.9				34.7						
	Average		36.7				37.2						
13	Tmax	38.8	38.1				38.4		32.2				
	T min	34.8	32.8				34.7		27.7				
	Average	36.9	36.1				36.7		29.5				
14	Tmax		38.9				37.9		33.2				
	T min		33.2				33.5		23.7				
	Average		37.0				35.9		28.2				
15	Tmax	37.5											
	T min	32.9											
	Average	35.1											



Fig. 3. X-ray of the right, unoperated knee and the left knee after the knee replacement surgery with clear signs of adhesions around the patella of the operated joint.

Table 2. Skin temperatures in the postoperative scar area on the operated knee after (1) and (2): where (1) – left knee replacement surgery; (2) – the revision TKR surgery with resurfacing of the patella and removal of adhesion masses; a – operated knee; b – unoperated knee.

Skin temperature, (°C)	Before the surgery (1)		Directly after the surgery (1)		2 weeks after the surgery (1)		Before the surgery (2)		Directly after the surgery (2)		2 weeks after the surgery (2)	
	a	b	a	b	a	b	a	b	a	b	a	b
Tmax	34.5	33.2	37.3	34.8	38.5	34.0	37.0	33.6	37.3	33.7	32.3	32.4
T min	30.0	28.1	27.7	30.8	34.9	33.1	35.2	28.1	27.5	28.1	28.9	28.1
Average	32.0	31.7	33.2	32.0	36.4	33.5	36.1	30.0	35.3	30.0	30.2	29.9

Conclusions

Although the results of the observation of temperature changes in the postoperative scar area suggest potential diagnostic value of thermography for the process of considering total knee replacement (TKR) revision surgery with patellar resurfacing and removal of patellar adhesion masses, clinical usefulness of skin temperature monitoring during the early rehabilitation period remains limited due to inconsistent measurement protocols, varying assessment schedules and insufficient reporting of patient demographics and clinical subgroups. However, we believe that skin temperature monitoring may still comprise a useful additional tool for early detection of inflammatory congestion and periprosthetic joint infection, especially when combined with other clinical indicators. We completely agree with the conclusions of Jesra, F. et al. (2025) that future studies should focus on large, well-characterised cohorts to establish standardised thresholds and integrate skin temperature monitoring indicators into multimodal diagnostic algorithms.

Conflicts of interest. The authors declare that there is no conflict of interest.

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