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THERMOGRAPHIC AND SONOGRAPHIC FINDINGS IN PATIENTS WITH KNEE PAIN: A RETROSPECTIVE STUDY FOR THE PERIOD JANUARY 2010 TO JULY 2023.

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SUMMARY/ABSTRACT

Our study is a retrospective study in which, from the total number of patients who were admitted to our institution for knee pain between January 2010 and July 2023, we selected only those who had a positive sonographic finding and were also examined thermographically. The total number of selected patients was 727. Of these, 321 were females and 406 were males aged 11 to 91 years. The mean age was 45 years. The number of positive sonographic findings was 2040. According to the nature of sonographic findings we divided them into: findings with liquid content (gangliomas, cysts, bursae, hydrops, haemarthrosis...) - total 36%. Findings of solid structure (calcifications, ossifications, osteophytes, mucoids, tophi, corpora libera) - 25% in total. Arthrosis femorotibial, femoropatellar - a total of 20%. Lesions (meniscopathies, tendinopathies, ruptures of tendons, muscles, ligaments, fractures, abruptions, usurations) - a total of 17%. Complications after TEP - 1%. Other (growing pains, plicae, chondrocalcinosis, aseptic osteonecrosis, tumors, nerve lesions) - 2% total. Of the 727 patients with sonographic abnormalities, 72% had a temperature distribution disorder. Of these, 67% of patients had hyperthermia of the painful knee, 5% had hypothermia. 28% of patients had a normal temperature pattern of the symptomatic knee compared to the contralateral knee.

KEYWORDS

thermography, sonography, painful knee, bursa, calcification.
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1 INTRODUCTION

The knee as an intermediate joint in the kinematic chain of the lower limb is a highly stressed anatomical region from a mechanical, thermal and vascular viewpoint. The knee is a complex joint consisting of the femorotibial joint supplemented by the medial and lateral menisci, the femoropatellar joint and the proximal tibiofibular joint. The strength of the joint is provided by 8 ligaments. They are lig. patellae, retinaculum patellae mediale, laterale, lig. collaterale laterale, lig. collaterale mediale consisting of a deep layer (lig. meniscofemorale, lig. meniscotibiale) and a superficial layer, lig. popliteum obliquum, lig. popliteum arcuatum, lig. tibiofibulare. Movement in the joint is made possible by the insertions and the beginnings of 15 muscles around the joint. These include m. adductor magnus, m. articularis, m. quadriceps femoris, m. semimembranosus, m. biceps femoris, m. sartorius, m. gracilis, and m. semitendinosus share a common tendon, the pes anserinus. M. tensor fasciae latae continues as the tractus iliotibialis and attaches to the tuberculum of Gerdy. M. tibialis anterior, m. peroneus longus, m. popliteus, m. plantaris, m. gastrocnemius caput mediale, m. gastrocnemius caput laterale. Smooth movement of the tendons and ligaments allows 24 bursae. These are: AI.1. Bursa mucosa praepatellaris s. prima, AI.2. Bursa mucosa praepatelaris subfascialis s. media, s. seconda, AI.3. Bursa praepatellaris subaponeurotica s. subtendinea, s. profunda, s. tertia, AII.1. Bursa mucosa subcruralis, AII.2. Bursa mucosa suprapatellaris intramuscularis accidentalis s. sutoria (bursa shoemakers), AII.3. Bursa mucosa suprapatellaris intramuscularis extensoris cruris, AIII.1. Bursa mucosa patellaris lateralis externa, AIII.2. Bursa mucosa patellaris lateralis interna. AIV.2. Bursa mucosa infrapatellaris superficialis inferior s. praespinosa, AIV.3. Bursa mucosa infrapatellaris profunda s. subligamentosa, BI.1. Bursa mucosa genualis lateralis interna superior, BI.2. Bursa mucosa genualis lateralis interna media, s. sub. ligamento genu laterale interno, BI.3. Bursa mucosa genualis lateralis interna inferior, s. b. m.tendinum musculorum sartorii, gracilis et semitendinosi, BII.1. Bursa mucosa genualis lateralis externa superior, s. sub. ligamento genu lateralis externo, BII.2. Bursa mucosa genualis lateralis externa inferior s. bicipito-fibularis, BII.3. Bursa mucosa genualis lateralis externa anterior s. b.musculi tensoris fasciae latae, BII.4. Bursa mucosa subcutanea fibularis, CI.1. Bursa mucosa supracondyloidea interna, CI.2. Bursa mucosa musculi gastrocnemii interni, CI.3. Bursa mucosa semimembranoso-gastrocnemialis, CI.4. Bursa mucosa semimembranosa, CII.1. Bursa mucosa retrocondylea externa propria s. profunda s. gastrocnemialis externa, CII.2. Bursa mucosa retrocondyloidea externa media s. bicipito-gastrocnemialis, CII.3. Bursa mucosa retrocondyloidea externa superficialis s. subcutanea, CII.4. Bursa mucosa poplitea subcutanea, CII.5. Bursa mucosa poplitea (22). The joint and periarticular structures are innervated by the n.saphenus, n.tibialis posterior, n.peroneus communis. The vascular supply is provided by the r.articularis a.genus superior lateralis a medialis, a.genus inferior lateralis a medialis, a.recurens tibialis anterior, r.articularis a.genus descendens.

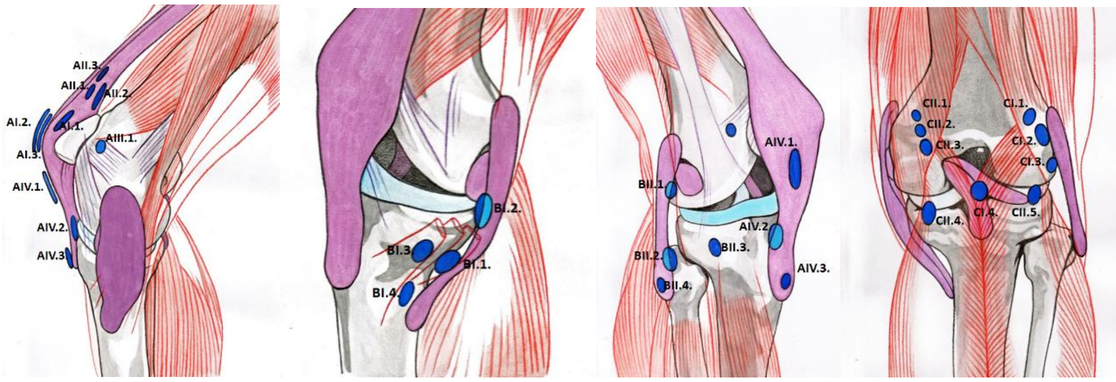

Fig.1a,b,c,d. Bursae anteriorly, medially, laterally, posteriorly (36).

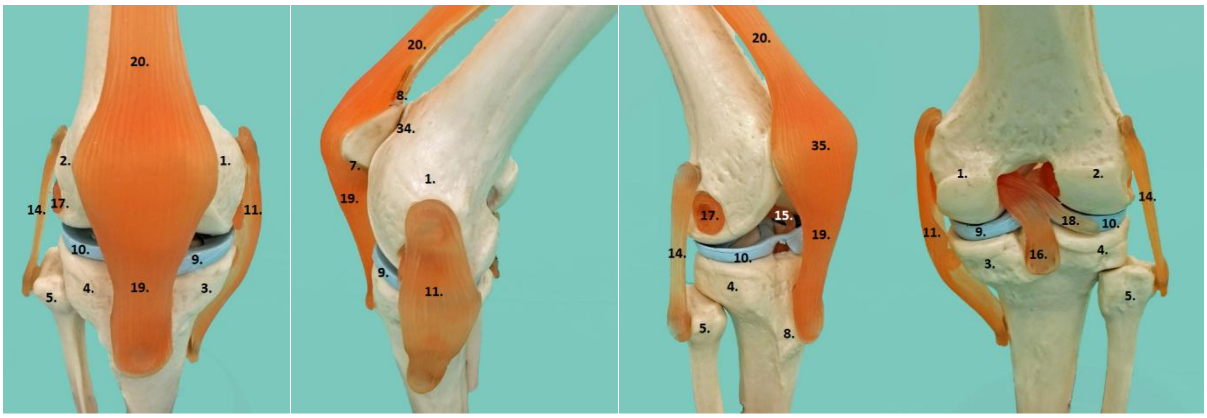

Fig.2.a,b,c,d. Osteoligamentous structures anteriorly, medially, laterally. 1.condylus medialis femoris, 2.condylus lateralis femoris, 3.condylus medialis tibiae, 4.condylus lateralis tibiae, 5.capitulum fibulae, 7.apex patellae, 8.basa patellae, 9.meniscus medialis, 10.meniscus lateralis, 11. ligamentum collaterale mediale, 14.ligamentum collaterale laterale, 16.ligamentum cruciatum

posterior, 17.tendo m. poplitei, 18.ligamentum meniscofemorale posterior,19.lig. patellae, 20.tendo m. recti femoris, 34.trochlea femoris (36).

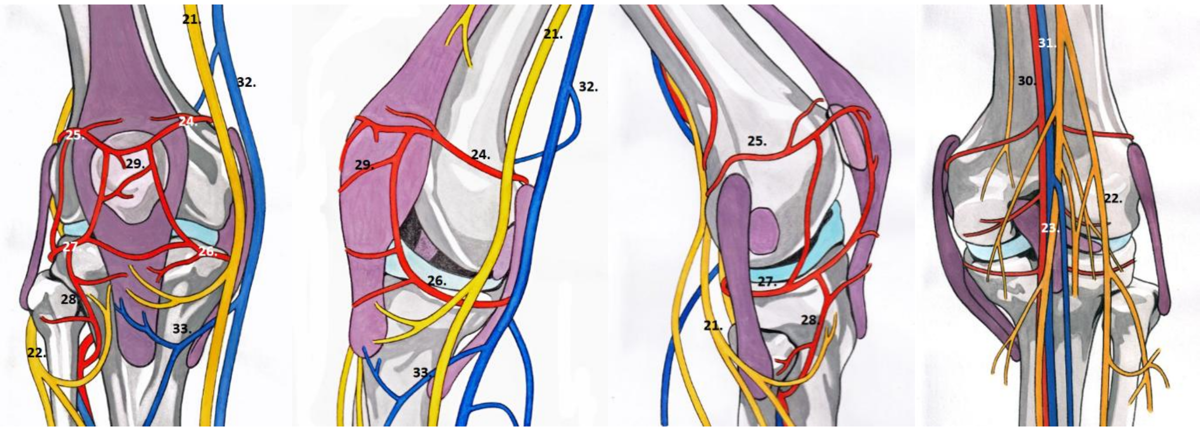

Fig.3a.b.c.d. Neurovascular structures anteriorly, medially, laterally, posteriorly. 21.n. saphenus, 22.n. peroneus communis, 23.n. tibialis, 24.a. genus superior medialis, 25.a. genus superior lateralis, 26. a. genus inferior medialis, 27.a. genus inferior lateralis, 28.a. recurens tibialis anterior, 29.rete articulare genus, 30.a. poplitea, 31.v. poplitea, 32.vena saphena magna, 33.v.genus (36).

The pain generator can manifest as a result of injury or disease of any of the anatomical structures of the knee joint. At the painful site, several physical and chemical stimuli can activate nociceptors and subsequently activate nociceptive pathways. Local inflammatory processes lead to nociceptive pain and, depending on the severity of the inflammation, an increase in skin temperature over the painful area. Pain can also lead to a disturbance of the balance in the autonomic nervous system, which may keep the pain distinct from nociceptive. Affected areas often have a low skin temperature, which can paradoxically react to heat input or output. However, pain may not be associated with altered skin temperature in many cases, as reported in patients with non-specific back pain. Thermal imaging provides information about the pathophysiological processes involved in various pain syndromes. However, thermography cannot accurately identify the anatomical structures where the activated nociceptors are located. For this purpose, imaging methods such as radiography (X-ray), magnetic resonance imaging (MRI), computed tomography (CT) or sonography must be used, which are able to show anatomical and tissue details. Over the past decade, the increased quality of ultrasonographic imaging has improved musculoskeletal diagnosis tremendously. It is possible to image deep lying structures. The improved contrast of the sonographic image allows easy differentiation of the structures under investigation. Thermographic and sonographic examinations are regularly performed at the first author's private rehabilitation medicine clinic, and findings related to back, knee, elbow, shoulder, hand and wrist, and hip pain have already been published. Since the knee joint is one of the sites of the most frequently experienced musculoskeletal pain, we decided to add another study to the series, this time focusing on the comparison of thermographic and sonographic findings with those of other imaging methods. The aim of this study was to classify knee pain by thermographic findings and to evaluate the sensitivity of thermography in relation to morphological findings recorded by sonography. Such knowledge can be useful in determining targeted treatment and an individually tailored treatment plan.

2 GROUP AND METHODS

From our institution's archives we selected patients who were admitted to our institution for knee pain between January 2010 and July 2023. Inclusion criteria were knee pain, abnormal sonographic findings of the knee joint, and thermal imaging of the knee joint area. I will briefly describe the standard procedure of medical examination at our workplace. After taking the medical history of all patients, they underwent a detailed musculoskeletal examination. The physical examination was supplemented by thermal imaging of the knee joints and sonographic examination. Other imaging methods were used in most patients.

Physical examination

The clinical examination includes recording the patient's medical history, particularly focusing on the characteristics of the pain: where and at which point the pain starts, the direction of pain spread, which conditions intensify or reduce pain, such as rest, movement, work, stress, relaxation, etc. Finally, examinations such as serological, X-ray, MRI... The physical examination includes a visual examination, focusing especially on abnormal vascular findings and superficial skin lesions. Palpation examination of the knee joint includes sensitivity tests of ligament and tendon attachments, evaluation of swelling and effusion. Functional tests were performed, which include range of motion (ROM) testing, evaluation of joint play, joint stability, and joint stiffness. Muscle strength and muscle tone were also tested.

Thermographic examination

For the thermographic examination, we used a Fluke Ti32 thermal imaging camera equipped with a 320 x 240 focal plane, uncooled microbolometer with a thermal sensitivity (NETD) of 0.05 °C at a 30 °C target temperature. The patient, with the examination area exposed, was equilibrated in a 25° ± 1.0°C dark room for 20 minutes. We recorded thermograms in the standard positions and views suggested in the Glamorgan protocol (2). In the produced thermograms, we evaluate the temperature values of Tmax, Tmean and Tmin from the region of interest according to the Glamorgan protocol. The normal temperature distribution is based on the so-called temperature symmetry, which is defined as the similarity of the mean temperature in the corresponding body region mirrored through the body's central axis (1,3). Temperature differences between corresponding areas of the body of less than 0.5 °C indicate a normal temperature distribution. A temperature decreases of 0.5°C or more compared to the reference area is a hypothermic pattern, while a temperature increase of the same value defines a hyperthermic pattern. In the case of temperature symmetry, a temperature deviation of 0.5 °C from the ambient temperature is referred to as local hyperthermia or hypothermia. We evaluated thermographically findings in the anterior, medial, lateral, and posterolateral regions of the knee joint.

Sonography

We used an Esaote MyLabSeven ultrasound machine with a 5-12 MHz linear probe for sonographic examination. We did not focus exclusively on the area of pain but examined the entire knee joint in each patient. When necessary, we used dynamic tests during the sonographic examination. During the anterior knee examination, the patient was lying supine with the knee slightly flexed. The medial examination was also performed with the patient in the supine position in full extension at the knee and in slight flexion. The lateral knee was examined in the same patient position as the medial knee. The posterior part of the knee was examined in the prone position of the patient.

3 RESULTS

The total number of patients enrolled in the study was 727. Of these, 321 were women and 406 were men, ranging in age from 11 to 91 years, with a mean age of 45 years. In several cases, the examinations were completed with other imaging modalities such as X-ray, MRI, CT. If necessary for the diagnostic decision, biochemical examination was performed.

Sonographic findings

According to the nature of the findings, we divided them into: findings with liquid content (gangliomas, cysts, bursae, hydrops, haemarthrosis...) - 36% in total; findings of solid structure (calcifications, ossifications, osteophytes, mucoids, tophi, corpora libera) - 25% in total. Arthrosis femorotibial, femoropatellar - a total of 20%. Lesions (meniscopathies, tendinopathies, ruptures of tendons, muscles, ligaments, fractures, abruptions, usurations) - a total of 17%. Complications of TEP - 1%. Other (growing pains, plicae, chondrocalcinosis, aseptic osteonecrosis, tumors, nerve lesions) - 2% total. The total number of positive sonographic findings was 2040. This means that several patients had two and some had more types of pathological findings.

Temperature distribution on the skin

Of the 727 patients with sonographic abnormalities, 72% had a temperature distribution disorder. Of these, 67% of patients had hyperthermia of the painful knee, 5% had hypothermia. 28% of patients had a normal temperature pattern of the symptomatic knee compared with the contralateral knee.

Table 1. Temperature patterns and associated sonographic findings.

Temperature pattern	**Number of patients 727**	**Number of sonographic findings 2040**
Hyperthermia (temperature of symptomatic knee joint at least 0.5°C higher than the temperature on the contralateral side)	487	Total: 1367 • Findings with liquid content (bursae, cysts, gangliomas, hydrops, haemarthrosis...)**:** 492 • Findings of solid structure (calcifications, ossifications, mucoids, tophi, corpora libera, osteophytes...): 342 • Arthrosis FP, FT: 260 lesions (meniscopathies, tendinopathies, tendon, muscle, ligament ruptures, fractures, abruptions...): 232 • TEP complications: 14 • Others (growing pains, plicae, chondrocalcinosis, aseptic osteonecrosis, tumours, nerve lesions...): 27
Hypothermia (temperature of symptomatic knee joint temperature at least 0.5°C lower than the temperature on the contralateral side)	36	Total: 102 • Findings with fluid content (bursae, cysts, gangliomas, hydrops, haemarthrosis...)**:** 37 • Findings of solid structure (calcifications, ossifications, mucoids, tophi, corpora libera, osteophytes...): 26 • Arthrosis FP, FT: 19 • Lesions (meniscopathies, tendinopathies, tendon, muscle, ligament ruptures, fractures, abruptions...): 17 • TEP complications: 1 • Others (growing pains, plicae, chondrocalcinosis, aseptic osteonecrosis, tumours, nerve lesions): 2
Normothermia (temperature difference between the two knee joints less than 0.5°C)	204	Total: 571 • Findings with liquid content (bursae, cysts, gangliomas, hydrops, haemarthrosis...)**:** 206 • Findings of solid structure (calcifications, ossifications, mucoids, tophi, corpora libera, osteophytes...): 143 • Arthrosis FP, FT: 108 • Lesions (meniscopathies, tendinopathies, tendon, muscle, ligament ruptures, fractures, abruptions...): 97 • TEP complications: 6 • Others (growing pains, plicae, chondrocalcinosis, aseptic osteonecrosis, tumors, nerve lesions):11

Tab.2.Sonographic findings and their temperature patterns.

Total sonographic findings 2040	↑T 1367	↓T 102	normT 571
Findings with fluid content (bursae, cysts, gangliomas, hydrops, haemarthrosis...)	492	37	206
Findings of solid structure (calcifications, ossifications, mucoids, tophi, corpora libera, osteophytes...)	342	26	143
Arthrosis FP, FT	260	19	109

Lesions (meniscopathies, tendinopathies, ruptures of tendons, muscles, ligaments, fractures, abruptions...)	232	17	97
TEP complications	13	1	6
Others (growing pains, plicae, chondrocalcinosis, aseptic osteonecrosis, tumours, nerve lesions)	27	2	11

Normal thermographic finding

It is characterized by symmetry of temperature pattern and absolute temperature parameters (Tmax, Tmin, Tmed) in all projections - anterior, posterior, medial and lateral. Anteriorly, hypothermia in the patella region is characteristic. Posteriorly in the fossa poplitea, there is increased thermal activity due to the course of a. poplitea and v. poplitea. Medially and laterally there is hypothermia over the femoropatellar and also over the femorotibial joint.

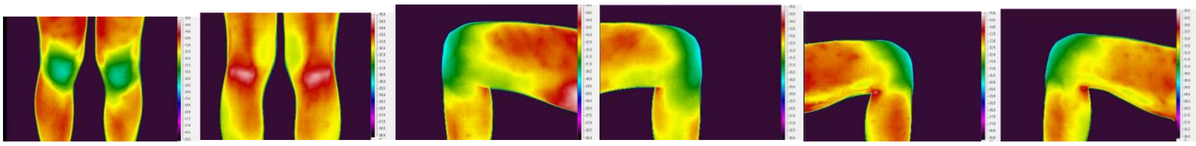

Fig.4a,b,c,d,e,f. Temperature findings anteriorly, posteriorly, medial right, left, lateral right, left.

Pathological sonographic and thermographic findings - examples

Knee anteriorly

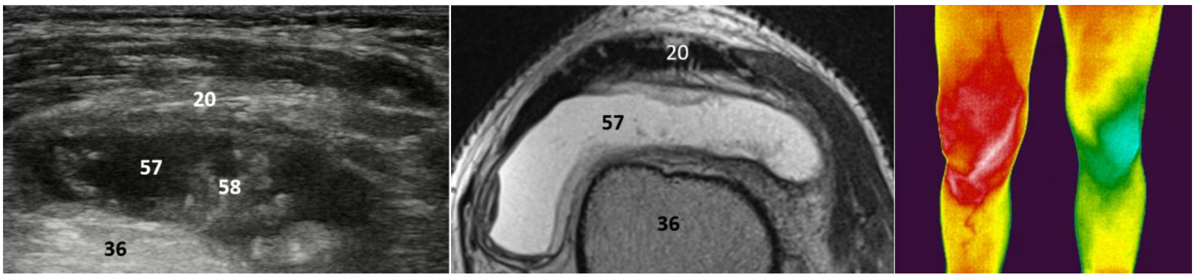

Fig.5a.Sono, Fig.5b.MRI, Fig.5c. TMV. Sono, MRI: villous synovial hypertrophy and hypoechogenic filling in the recessus suprapatelaris. TMV: high temperature activity of the right knee. 20.tendo m. recti femoris, 36.femur, 57.hydrops, 58.synovia.

Knee medial

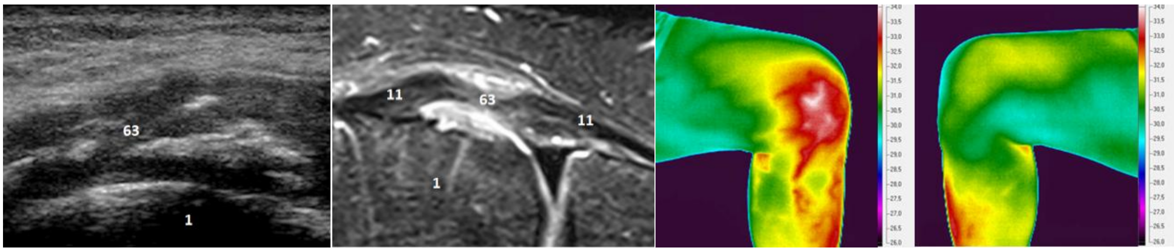

Fig.6a.sono, Fig.6b.MRI, Fig.6c.TMV. Sono, MRI: periosteal abruption of the LCM attachment to the medial femoral condyle. TMV: focal finding of increased thermal activity in medial part of left knee. 1. condylus medialis femoris, 11. ligamentum collaterale mediale, 63. rupture.

Knee lateral

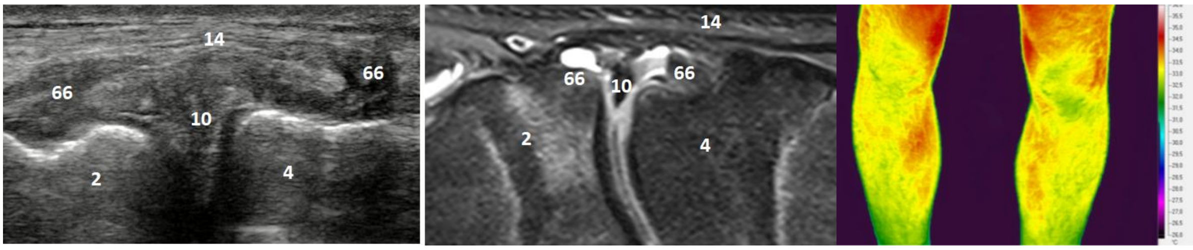

Fig.7a.sono, Fig.7b.MRI, Fig.7c.TMV. Sono,MRI: extrusion of lateral meniscus with perimeniscal cysts on the left. TMV: a focus of increased thermal activity in the lateral part of the left knee. 2.condylus lateralis femoris, 4.condylus lateralis tibiae, 10.meniscus lateralis, 14.ligamentum collaterale laterale, 66.cyst.

Knee posterior

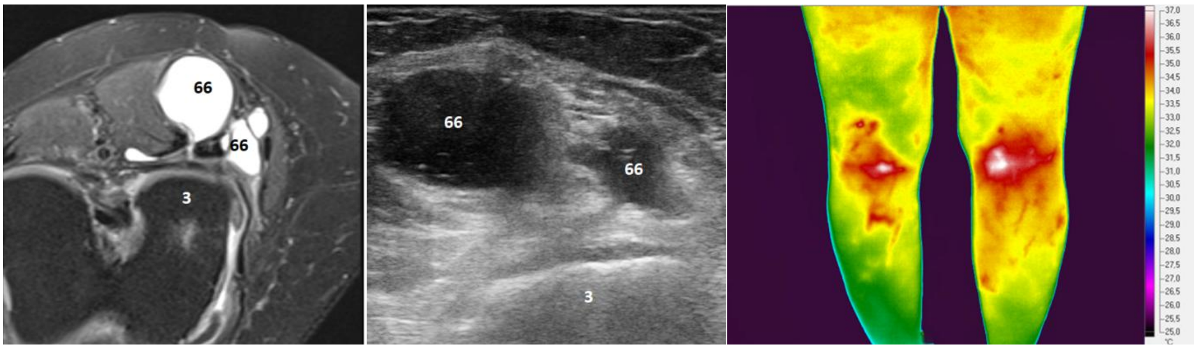

Fig.8a.sono, Fig.8b.MRI, Fig.8c.TMV. Sono, MRI: two deeper seated bursae in the medial part of fossa poplitea on the left. TMV: hypothermia on the left in PA projection. 3. condylus medialis tibiae posteriorly, 66. bursa.

Fracture

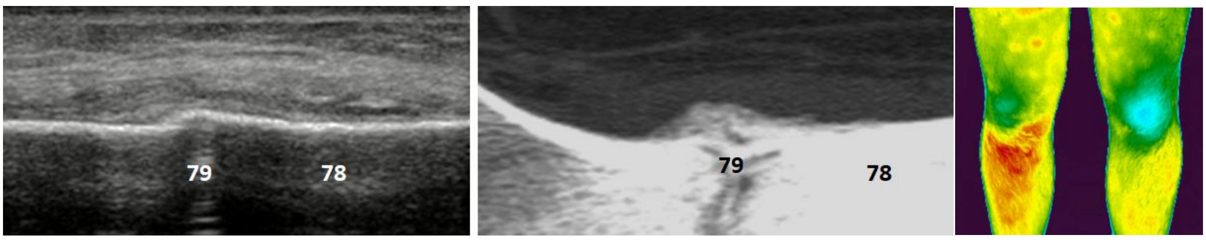

Fig.9a,sono Fig.9b.CT, Fig.9c.TMV. Sono,CT: fracture of the medial condyle of the tibia on the right. TMV: increased thermal activity of tibia proximal medially and anteriorly.78.tibia, 79.fracture.

Total endoprosthesis

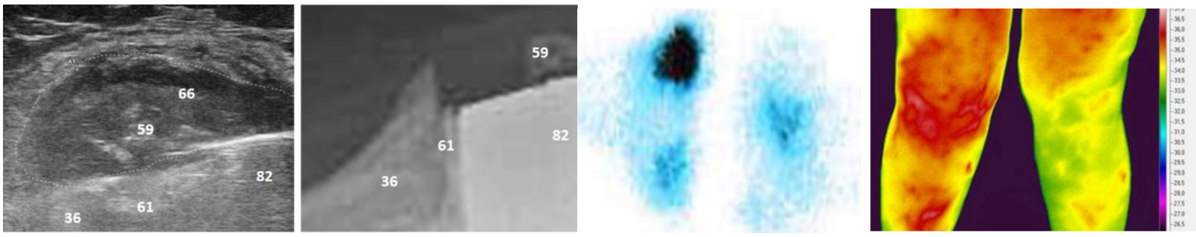

Fig.10a.sono, Fig.10b.X-ray, Fig.10c.scinti, Fig.10d.TMV. Sono, X-ray: defect between femoral component of TEP and femur, ganglion with ossification above. Scinti: increased uptake of radiopharmaceutical in the TEP area on the right. TMV: increased thermal activity of the right knee. 36. femur, 59. calcification, 61. defect, 66. ganglioma, 82. TEP.

Growth pains

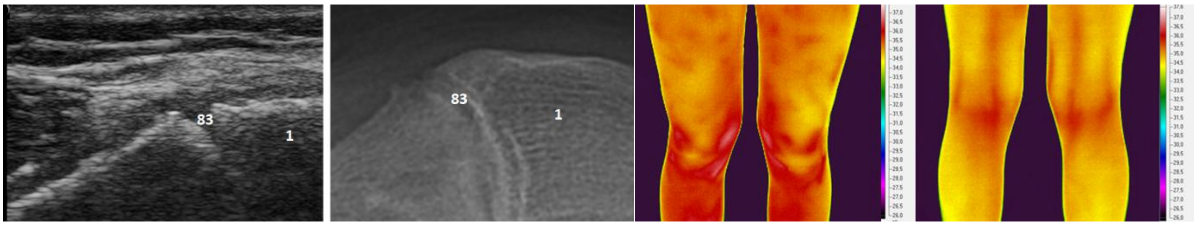

Fig.11a.sono, Fig.11b.radiograph, Fig.11c.TMV AP, Fig.11d.TMV PA. Sono, X-ray: normal findings of growth plates. TMV: increased thermal activity in the area of growth plates of medial and lateral femoral condyles and tibiae bilaterally. 1. condylus medialis femoris, 83. growth plate.

Juvenile rheumatoid arthritis

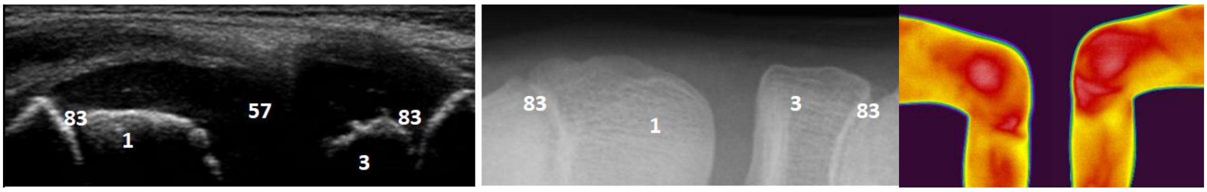

Fig.12a.sono, Fig.12b.radiograph, Fig.12c.TMV medially. Sono: hypoechogenic filling of the recessus genus medialis. X-ray: normal findings of growth plates. TMV: increased thermal activity of the medial articular recessus and in the area of the growth plates of the medial condyle of the femur and tibia bilaterally. 1. condylus medialis femoris, 3. condylus medialis tibiae, 57. hydrops, 83. growth plate.

4 DISCUSSION

Ammer analyzed the temperature of 3463 knees based on a literature search of the Medline and Embase databases. 876 were healthy subjects, the rest had various types of diseases such as arthritis, rheumatoid arthritis, non-rheumatoid arthritis, post-traumatic temperature elevation, ligament and fibrocartilaginous injuries, algodystrophy, temperature measured during and after surgery. The methods of contact measurement, radiometry, thermography were used to measure the temperature. The measured temperatures varied according to the method used. Measurement of only the average temperature describes the knee disease incompletely; it must be supplemented by a description of the temperature distribution - the temperature pattern (4). In our previous works, we have described the changes in knee temperature pattern in different types of knee injuries and diseases based on the analysis of 5000 knee thermograms in all projections given by the Glamorgan protocol for the period 1985-2012, so that they can be used in the differential diagnosis of different types of knee damage and disease - growing pains, rheumatoid arthritis and other types of arthritis, aseptic necrosis, hydrops hemartros, distorsions, distensions, ligament ruptures, bursopathies, cysts, enthesopathies, and pain maintained by sympathetic (32,33). Jerosch and Schröder examined 101 patients with acute or chronic knee pain. They compared the results of preoperative sonographic examination with arthroscopic findings. A less experienced sonographer achieved an accuracy and predictive value of 81% for the medial meniscus and 80% accuracy for the lateral meniscus, but a lower predictive value of 7% because of the high number of false-positive findings. The more experienced sonographer had an accuracy of 83% and a predictive value of 91% for the medial meniscus. For the lateral meniscus, the accuracy was 89%, the predictive value 22%. Both investigators were unable to detect LCA rupture with certainty (5). Rabello and colleagues, comparing 38 patients with unilateral patellar tendinopathy with 25 asymptomatic controls, found that there was a significantly higher incidence of patellar tendinopathy on the asymptomatic side in the patients. A possible explanation is the cross-transfer effect - an interhemispheric interaction commonly observed in muscle. This means that a comparison of the symptomatic side with the asymptomatic side cannot be used as a reference value. They offer a division of sonographic findings into 4 types, with initially intact and aligned tendon bundles changing to less integrated and undulating tendon bundles and through fibrillar tissue disruption to an image of a predominantly amorphous matrix with loss of fibrillarity, cells, and fluid (6). Švaic and colleagues quantified the effect of local skin folds, body temperature, ambient temperature, body mass index, and gender on knee temperature. Knee temperature in women was not statistically different from that in men. Skin thickness did not correlate significantly with knee temperature. Body mass index and knee skinfolds showed no significant effect on anterior knee temperature in healthy subjects (7). Romanò and colleagues compared the temperature patterns of wound healing after total knee arthroplasty in 40 patients with an uncomplicated course without infection with thermograms from patients with knee arthroplasty infection. At the same time, FW, CRP, and radiographs were monitored. CRP was corrected 20 days after surgery, FW was elevated even 3 months after surgery. With an uncomplicated course, the temperature parameters and temperature pattern normalized within 90 days after surgery. In TEP complicated by infection, elevated knee temperature persisted after 90 days, although there were no clinical signs of inflammation. If the temperature does not fall for 90 days or a new peak appears, this is indicative of infection. CRP and FW can also increase with infection elsewhere in the body, that is why thermography is more specific (8). In our observations described in our last study, we observe increased thermal activity in the knee area after TEP even in cases of noninfectious TEP rejection, concomitant with increased radiopharmaceutical uptake in the TEP area (36). Mayr also tracked the evolution of the knee's temperature pattern after TEP. He detected not only inflammation, but in some cases also reflex sympathetic dystrophy. In his group of patients, normalization of temperature parameters after TEP occurred within 9 weeks. He reports that after partial knee arthroplasty, temperature changes are less than after TEP (16). Bozic and colleagues report that of 60355 knee TEP revisions in the USA, infection is the most common cause, accounting for 25% of cases (9). Endstrasser and colleagues describe a significant reduction in physical activity, faster progression of pain in knee osteoarthritis in 63 patients with a delayed TEP term due to lockdown during the covid epidemic (10). Giorgino and colleagues, analyzing 1139 patients, found a significant worsening of patellofemoral pain due to lockdown in a covid pandemic (11). Bahsi and colleagues detected sonographic change in cartilage thickness in the trochlea femoris after long-term isometric and isotonic exercises in osteoarthritis of the knee. Cartilage thickness increased in both groups, significantly with isotonic exercises (12). Given the high number of FT and FP arthroses (19%) found in the analysis of 2040 positive sonograms in 727 patients in our study, this is an important finding for rehabilitation practice (36). Molina-Paya and colleagues confirmed that the intratendinous Doppler signal in the patellar tendon, is a reliable and reproducible investigation of patellar tendinopathy in the case of additional processing of 4s video by special software. A Doppler signal without this processing is not always a signal of a pathological disorder, but rather an adaptive response to a normal physiological load (13). Kenton and coauthors reached similar results when examining the patellar tendon in 22 runners and 11 controls. Sono examinations were performed at the beginning and end of the season. Collagen organization, mean echogenicity, tendon thickness, and neovascularity were examined. At the end of the season, the collagen fibers were aligned and the patellar tendon hypertrophied. A certain degree of tendon remodeling serves as a protective adaptation to a specific sport load (18). Tang and co-authors show in histochemical studies that tendinopathies previously thought to be degenerative are of inflammatory origin. They detail the development of inflammatory changes, the role of inflammatory mediators, cytokines, complement, immunocytes, monocytes, macrophages, tendon stem/progenitor cells (TSPCs), TNF-α, and interleukins. The importance of substance P and mast cells for the development of neurogenic inflammation. The importance of alarmin molecules that are released from dead cells. Gradually, however, the influence of inflamatory milieau leads to hypertrophy and hyperplasia of tenocytes. TSPCs can differentiate not only into normal tendon cells but also into fat, bone, and cartilage cells, resulting in heterotopic ossification and fatty infiltration of the tendon (14). That tendinopathy undergoes different stages of development has been confirmed by long-term observation of the development of the temperature pattern in our previous works. Different temperature patterns of tendinopathies are also observed in our latest study. From hyperthermic in the acute stage, to normal to hypothermic (36). Knowing what stage the tendinopathy is in is important for treatment. Antiflogistic treatment applied at an inappropriate stage, especially the application of glucocorticoids, can have a detrimental effect on the tendon in the long term. The authors recommend to support the self-healing capacity of the body by using growth factors contained, for example, in plasma, mesenchymal cells and biomaterial (14). Chhem indicates that local application of steroids is one of the causes of rupture of the tibial insertion of the lig. patellae. He describes numerous bursae around the knee and the importance of ultrasound in locating them (39). The occurrence of a large number of bursae is confirmed in our recent study (36). Pimentel, Abicala, and coauthors, in a sonographic and radiographic examination of 100 patients with osteoarthritis, found that the most frequent sonographic finding was joint filling (20). The high frequency of findings with fluid content (bursae, cysts, gangliomas, hydrops, haemarthrosis...) - 36%, is also confirmed in our study (36). Maffulli and colleagues sonographically examined 52 knees and noted patellar tendon lesion and Backer's cyst as the most common findings (21). In our study of 727 patients with 2040 positive sonographic findings, tendon and other lesions ranked fourth in frequency with 17%. Findings with liquid content, which includes Backer's cyst, were the first with 36% frequency (36). In a study of 25 patients with post-traumatic knee who underwent rehabilitation, Nica objectified the results by functional parameters (pain, stiffness, muscle strength), radiography, sonography, and thermography. Data were analyzed before and after rehabilitation (over 14 days). The thermographic results correlated with the dynamics of the development of other parameters studied (17). Wakefield and colleagues describe hypoechogenicity in the region of the growth plates. They describe the differences of patellar and tibial attachment of lig. patellae in children. We confirm these findings in our recent study and in previous studies. They do not consider the synovitis in juvenile rheumatoid arthritis identified by Doppler to be specific in determining the cause (38). The finding of synovitis in juvenile arthritis is confirmed even in our studies. It differentiates pain in juvenile arthritis from growing pains, in which synovitis is not present (35). In our previous works evaluating the temperature patterns of young athletes and nonathletes, we have noted differences in the temperature pattern from that of adolescents without knee pain (28,29,30). We continued to monitor the temperature pattern of the knees of the young athletes even in combination with sonographic examination. In continuing works, we have described the temperature patterns of various types of knee damage and disease, growth pains, and juvenile rheumatoid arthritis in relation to structural sonographic findings (31). In the study that followed, we compared the temperature patterns of 44 pediatric patients with knee pain and 15 asymptomatic athletes. Differences in the temperature pattern of the knees of adolescents with growing pains and the normal temperature pattern are described. Increased temperature activity over the growth plates coincides with increased radiopharmaceutical uptake on scintigraphic examination (35). In the present study, we evaluated sonographic findings according to the frequency of different types of damages and diseases in combination with thermal imaging findings and findings of other imaging modalities - MRI, X-ray, CT, scintigraphy (36). Jacobson, Marcelis, and Novotny describe the same findings that we describe in our series of 727 patients with 2040 positive sonographic findings, but they do not report the frequency of each type of finding or the numbers of patients examined by them (37,40,19). Vasdev and colleagues examined 50 patients with rheumatoid arthritis and 50 asymptomatic control subjects thermographically and sonographically. They found a strong correlation between sonographic examination and knee-thigh temperature differentials. They observed statistically significant differences in mean knee temperature as well as mean knee-thigh temperature difference during inflammatory activity compared to control knees (15). In one of our previous papers, in which we examined 99 patients, we found thermographically elevated temperature activity in 76 cases and sonographically extraarticular findings in 82 cases (34). Wakefield and colleagues, in an examination of 22 patients with rheumatoid arthritis, found joint filling, bursae, and cysts in 42% of cases (38). Our recent study with 727 patients and 2040 positive sonographic findings also had the highest frequency of findings with fluid content (bursae, cysts, ganglioma, hydrops, hemarthros...) at 36%, although these were not exclusively rheumatic patients (36). Hornáček and co-workers pointed out that thermographically captured asymmetric pathological temperature patterns also indirectly reflect various pain characteristics, specifically and statistically significantly its intensity. They also found that women are statistically significantly better able to subjectively capture and express thermographically recorded temperature changes compared to men, assessing correlated pain using the Melzack Pain Questionnaire and the Visual Analog Scale (41). Also for this reason, our work, in which women constituted almost half of the examined persons, is an expression not only of the objective findings and their correlations between the different examination methodologies, but also of the subjective experience of pain in the diverse spectrum of pathological findings observed and its correlation with the objectively detected pathological findings. And thus, our findings provide a more comprehensive picture.

5 CONCLUSIONS

The combination of physical and thermographic examination with sonographic examination has greater diagnostic accuracy than thermographic or sonographic examination alone. It allows us to choose targeted and tailored treatment.

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