Thermographic and ultrasound findings of patients with pain of hip joints: retrospective study from April 2010 to July 2022.

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SUMMARY

A retrospective review of medical records was performed to identify patients who attended a private clinic for rehabilitation medicine in Trencin between April 2010 and July 2022, where their hip joint pain was evaluated by physical examination in combination with thermographic and sonographic imaging. Pain was classified with respect to the skin temperature over the symptomatic hip joint, and alterations in anatomical structures were suspected by physical examination and confirmed by sonography. Data were included from 232 patients, 133 males and 99 females. While sonography obtained conspicuous findings in all patients, 42% of patients presented with increased temperature over the affected hip joint, and 17% showed reduced temperature over the affected hip joint. The remaining 41% of patients showed a symmetrical skin temperature distribution between hip joints. Examples of normothermic, hypothermic and hyperthermic temperature patterns and their corresponding sonographic findings are provided.

KEY WORDS: Thermography, Sonography, painful hip joint

THERMOGRAFISCHE UND SONOGRAFISCHE BEFUNDE BEI PATIENTEN MIT HÜFTSCHMERZEN: RETROSPEKTIVE STUDIE VOM APRIL 2010 BIS JULI 2022

Es wurde eine retrospektive Durchsicht der medizinischen Aufzeichnungen durchgeführt, um Patienten zu identifizieren, welche die private Ordination für Rehabilitationsmedizin in Trencin im Zeitraum zwischen April 2010 und Juli 2022 aufgesucht hatten, wobei deren Hüftschmerz durch körperliche Untersuchung in Kombination mit Wärme- und Ultraschallbildern evaluiert wurde. Schmerz wurde über der symptomatischen Hüfte mit der Hauttemperatur in Beziehung gesetzt, und Veränderungen der anatomischen Strukturen wurden durch die körperliche Untersuchung vermutet und sonografisch bestätigt. Befunde von 232 Patienten, 133 Männer and 99 Frauen wurden eingeschlossen. Während in der Sonografie bei allen Patienten verdächtige Befunde erhoben wurden, zeigten 42% der Patienten eine erhöhte Temperatur und 17% boten eine verminderte Temperatu an der betroffenen Hüfte. Die restlichen 41% der Patienten zeigten eine symmetrische Verteilung der Hauttemperatur über den Hüftgelenken. Bespiele normothermer, hypothermer und hyperthermer Temperaturmuster und ihrer entsprechenden sonografischer Befunde werden gezeigt.

KEY WORDS: Thermografie, Sonografie, schmerzhafte Hüfte

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Introduction

The hip joint is a spherical joint, composed of head and fossa, which is completed by fibrous cartilage. Fibrous cartilage increases the margins of the fossa. The joint capsule is strengthened by 4 ligaments: lig. iliofemorale, lig. pubofemorale, lig.ischiofemorale and zona orbicularis. The next 2 ligaments are lig. transversum acetabuli and lig. capitis femoris. 23 muscles begin or are anchored around the hip joint. There are 10 primary muscles of the hip joint. The anterior group is formed by the m.iliopsoas. The posterior group is composed of: a) superficial muscles - m.gluteus maximus, m.gluteus medius, m.gluteus minimus, m.tensor fasciae latae, b) deep muscles, so-called pelvitrochanteric - m.piriformis, m. gemelus superior, m.gemelus inferior, m.obturatorius internus, m. quadratus femoris.

There are 10 muscles of the thigh. The ventral group of thigh muscles are m.sartorius and m. quadriceps femoris. M.quadriceps femoris is composed of m.rectus femoris, m.vastus medialis and m. vastus lateralis. M.rectus femoris has 2 origins - caput rectum and caput reflexum. The medial group of thigh muscles are m.pectineus, m. adductor longus, m. gracilis, m.adductor brevis, m.adductor magnus and m. obturatorius externus. The dorsal group of thigh muscles is composed of m.biceps femoris - caput longum, m. semitendinosus and m. semimebranosus [1].

The hip joint is innervated by a number of nerves. The medial and front part is innervated by rr. articulares n. obturatorii. The anterior and lateral part is innervated by rami articulares n. femoralis. The caudal part is innervated by ramus articularis n. ischiadici, rami articulares n. gluteus superior and n. gluteus inferior. The vascular supply is provided by a.femoralis, a.glutea superior, a. glutea inferior, a.

circumflexa femoris medialis and a.circumflexa femoris lateralis [2].

Around the hip joint 21 bursae occur, which mediate gliding movement of the muscles. Bursae are structures closely associated with tendon sheaths. The lining of the bursa is a smooth vascular synovial membrane, which has lower coefficient of friction. It facilitates sliding of the tissue near the bursa. Even though 21 bursae are described aroud the hip joint, the official anatomical terminology presents only 3 of them: on the front part of the hip bursa iliopsoatica, a complex of epitrochanteric bursae (which are in relation with the abductor mechanism) and 3 caudal ischiogluteal bursae [3]. The nomenclature of bursae is combined with their anatomical location.

The growth of the joint is mediated partially genetically. Biomechanical factors are the main influence on the development and formation of the hip joint. Coxarthrosis is a degenerative process of the hip joint cartilage. Consecutive changes of the joint capsula and the muscles develop gradually. When the static and biomechanic force on a joint is changed, the lower limb may become shorter. Different biomechanical and biological factors can lead to cartilage damage. The causation of primary coxarthrosis is unknown. Mechanical and biological factors are important for the maturing of mesenchymal tissue. Secondary coxarthrosis is developed after joint disease - infection, rheumatic inflammation, Mb.Perthes, fracture, dysplasia of the hip joint and others. In patients younger than 40 years it is necessary to use all of the conservative healing possibilities. After 55-60 years of age, a total end prosthesis (TEP) is implanted in painful patients with ROM limitation and coxarthrosis III.-IV.degree [4].

A pain generator may occur following an injury or disease in any of the anatomical structures of the hip joint. At the painful site, several physical and chemical stimuli can activate nociceptors and subsequently activate nociception pathways. Local inflammatory processes lead to nociceptive pain, and depending on the severity of the inflammation skin temperature is increased over the painful area. Pain may also result in a disturbed balance within the autonomic nervous system, which may be maintained and became dissociated from the original nociception. Affected regions often present with low skin temperature that may respond paradoxically to heat supply or heat removal [5]. However, pain may not be associated with an altered skin temperature in several cases, as reported in patients with non-specific back pain [6]. Thermal imaging provides clues to the pathophysiological processes involved in various pain syndromes. However, thermography fails to accurately identify the anatomical structures where activated nociceptors are located. For that purpose, imaging methods such as radiography, magnetic resonance imaging (MRI), computed tomography (CT), or sonography must be used because they are able to resolve anatomical and tissue details [7]. Over the last decade, the quality of ultrasonographic imaging has enormously improved the diagnosis of disorders of the musculoskeletal system. It is now possible to display deep-lying structures, and the sonographic image has an improved contrast that enables easy differentiation of the examined structures [8]. Thermographic and sonographic examinations are regularly performed in the first author´s private clinic of rehabilitation medicine and findings related to back pain [9], knee [10], elbow pain [11] and shoulder pain [12] have already been reported. Since the hip joint is amongst the most frequently experienced pain locations of the musculoskeletal system, we decided to add another report to this series of thermographic and sonographic findings, focusing this time on findings in patients with painful hip joints. The aim of this study was to classify hip joint pain by thermographic findings, and to evaluate the sensitivity of thermography in relation to the morphological findings recorded by sonography. Such knowledge might be useful in developing a targeted treatment and an individually-tailored treatment plan.

Method

We searched in the archive of medical records of our private clinic for patients who were medically evaluated due to hip joint pain in the period from April 2010 to July 2022. Inclusion criteria were hip joint pain, abnormal findings in hip joint sonography and recorded infrared thermal images. The standardised procedure of the medical examination in our clinic was described in detail elsewhere in patients with elbow pain [11]. In brief, a medical history was recorded in all patients and they underwent a detailed musculoskeletal examination. The physical examination was completed by a sonographic assessment and thermal imaging of the painful region.

Physical examination

The clinical examination included a record of each patient´s medical history, especially focusing on pain characteristics: when and at what site pain started at first, the direction in which the pain spread, what conditions aggravate or reduce the pain such as rest, movement, work, stress, relaxation and so on. At the end of this interview, externally realised investigations such as blood tests, radiographs or MRIs were collected. The physical examination included inspection with a particular focus on abnormal vascular findings and superficial skin lesions. Palpation of the hip joint included testing for tenderness of insertions of ligaments and tendons, assessment of swelling, thickened synovial folds and effusions. Functional tests were performed including range of motion, assessment of joint play, joint stability and joint stiffness. Muscle tone and muscle strength were also tested.

Thermal imaging

For thermal imaging, we used the Fluke infrared camera Ti32, equipped with a 320 x 240 focal plane array, uncooled microbolometer with thermal sensitivity (NETD) 0.05 °C at 30 °C target temperature. The patient, disrobed other than a small thin covering of intimate areas, was equilibrated in a darkened room at 25° ± 1.0°C for 20 minutes. The analysis of thermal images was based on the extraction of the temperature values Tmax, Tmean and Tmin from regions of interest as proposed in the Glamorgan Protocol [13]. Normal temperature distribution is based on the so-called thermal symmetry, which is defined as the similarity of mean temperatures in corresponding body regions mirrored across the median body axis. Differences in temperature between corresponding body regions less than 0.5 °C indicate a normal temperature distribution. Compared to the reference site, a temperature decrease by 0.5 °C or more is named the hypothermic pattern, while an increase in temperature of the same magnitude defines the hyperthermic pattern. In the case of thermal symmetry, deviations in temperature of 0.5°C to the surrounding temperature are labelled as local hyperthermia or hypothermia respectively. Thermographically, we evaluated findings in the anterior, lateral and posterior areas of the hip joint and findings in the thigh area.

Sonography

We used an Esaote MyLabSeven ultrasound device with a 5-12 MHz linear probe to perform the sonographic examination. We did not focus exclusively on the painful area; but rather examined the entire hip joint in each patient. Dynamic tests were included in the sonographic evaluation when necessary.

Results

The total number of patients selected was 232. Of these, 99 were women aged between 18 and 83 years (with the average of 55 years) and 133 were men aged between 11 and 79 years (with the average age of 45 years). In most of the cases the examinations were completed with other imaging methods such as radiography, MRI or CT scans. Biochemical examinations were performed as well, if required for a definite diagnostic decision.

Table1.
Thermal patterns and sonographic findings

Thermal pattern	Number of patients (232)	Number of sonographic findings (397)
Hyperthermia (temperature at the symptomatic hip joint higher by at least 0.5 °C than the temperature of the contralateral side)	97	Total: 167 Coxarthrosis I.,II.st.: 8% Coxarthrosis III., IV.st.: 3% Lymphadenopathy, lipomas, fibromas, fibrotization: 4% Bursae, cystae: 17% Calcifications, osteophytes: 45% TEP: 4% Traumas: 8% Thigh: 11%
Hypothermia (temperature at the symptomatic hip joint at least 0.5 °C lower than the temperature of the contralateral side)	40	Total: 67 Coxarthrosis I.,II.st.: 5% Coxarthrosis III., IV.st.: 58% Lymphadenopathy, lipomas, fibromas, fibrotization: 10% Bursae, cystae: 10% Calcifications, osteophytes: 21% TEP: 2% Traumas: 2% Thigh: 2%
Normothermia (temperature difference between hip joints less than 0.5 °C)	95	Total: 163 Coxarthrosis I.,II.st.: 2% Coxarthrosis III., IV.st.: 8% Lymphadenopathy, lipomas, fibromas, fibrotization: 10% Bursae, cystae: 17% Calcifications, osteophytes: 53% TEP: 2% Traumas: 6% Thigh: 2%

Table2.
Sonographic findings and their temperature patterns

Sonographic findings total 397		↑T%	↓T%	normT %
Coxarthrosis I.,II.	49	54%	33%	13%
Coxarthrosis III., IV	28	4%	84%	12%
Lymphadenopathy, lipomas, fibromas, Fibrotization	29	28,5%	0%	71,5%
Bursae, cystae	47	36%	21%	43%
Calcifications, Osteophytes	194	38%	17,5%	44,5%
Traumas	19	50%	12,5%	37,5%
TEP	7	50%	25%	25%
Thigh	24	69%	12,5%	18,5%

Sonographic findings

According to the character of sonographic findings we divided them into:

- Lymphadenopathies, lipoms, fibroms, fibrotization in total number 29, of these anteriorly 20, posteriorly 9.
- Bursas and cysts in total number 47, of these anteriorly 15, laterally 22, posteriorly 10.
- Calcifications and osteophytes in total number 194, of this anteriorly 82, laterally 74, posteriorly 38.
- Bone and muscle traumas in different areas in total number 19.

In 7 patients, complications after TEP were evaluated. In 77 cases, patients with coxarthrosis were examined, by degree of these: 1st stage 25 patients, 2nd stage 24, 3rd stage 22, 4th stage 6. The number of pathological structural findings in the thigh area was 24. The total number of pathological findings of the examined patients was 397. This means that several patients had two or more types of pathological findings.

Temperature distribution over the skin

Only 59% of the 232 patients with sonographic abnormalities showed a disturbed temperature distribution. 42% of patients presented with hyperthermia in the painful hip joint region, while 17% of patients showed low temperatures over the symptomatic hip joint. There were 41% of patients whose thermal pattern in the painful hip joint region was similar to that of the unaffected side.

Normal temperature patterns

Typical normal temperature distributions at the anterior, lateral and dorsal sites of the hip joint recorded in subjects free of symptoms are presented in figure 2a-2d. We observed symmetric hypothermy in the gluteal area, which was combined with a higher temperature in the proximal part of the intergluteal groove and a butterfly pattern of slightly increased temperature over the sacroiliac area, plus a continuous narrow strip with higher temperature over the processi spinosi of the lumbar spine. Slightly increased temperature activity was observed in the lateral projection in the area of muscle insertion into the front part of crista iliaca and spina iliaca anterior superior.

Pictures 3, 4, 5, 6 show thermograms of the temperature distribution of patients with hyperthermia and hypothermia in the hip joint area. In pictures 7, 8, 9, 10 are sonographic findings.

Figure 2a.
Hip joint anterior

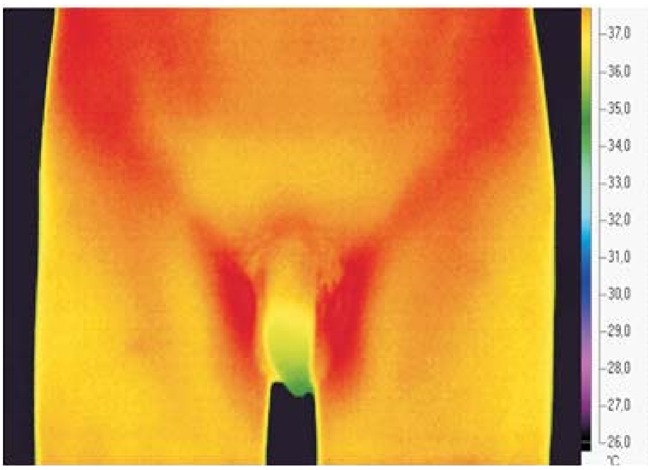
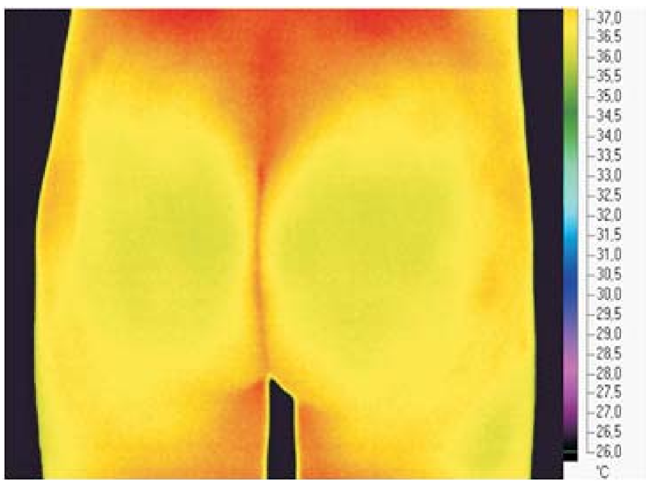


Figure 2b.
Hip joint posterior



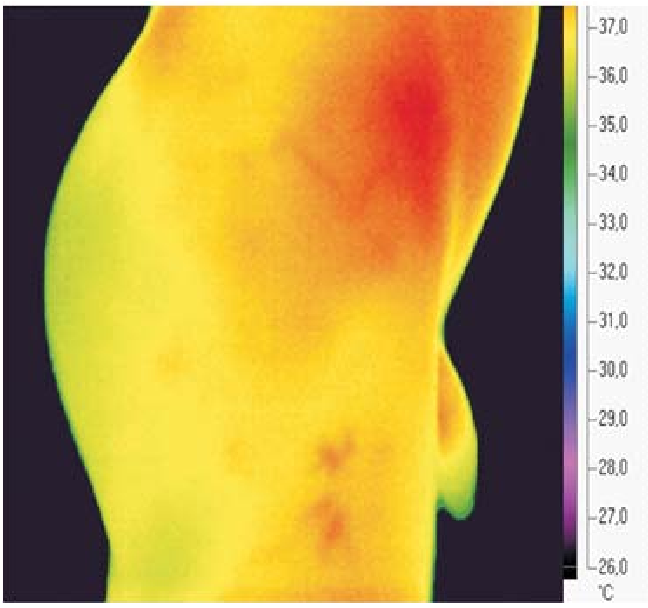


Figure 2c.
Hip joint lateral right side

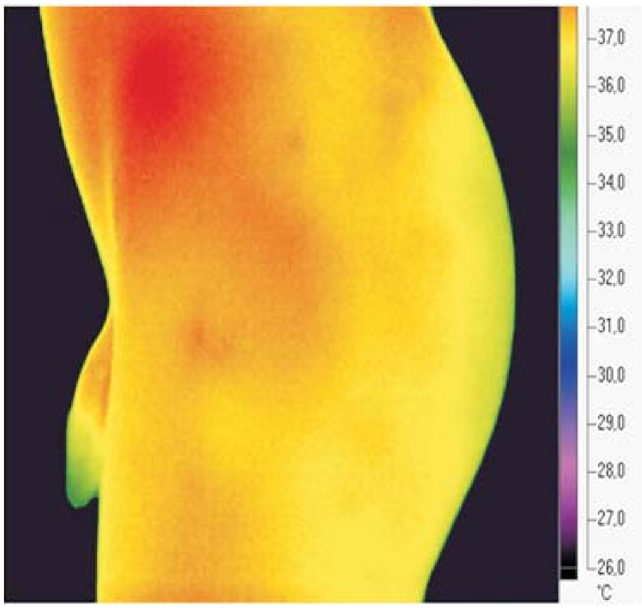


Figure 2d.
Hip joint lateral left side

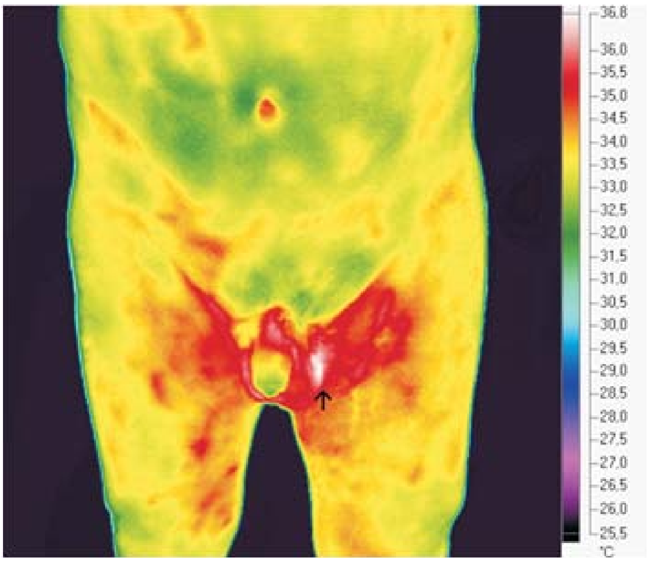


Figure 3.
Thermography ↑ increased temperature activity on the left

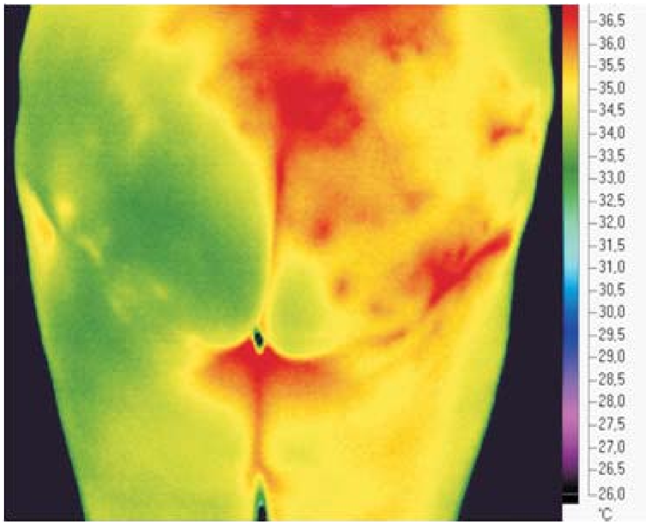


Figure 4.
Thermography ↓ hypothermia on the left side in coxarthrosis IV.st

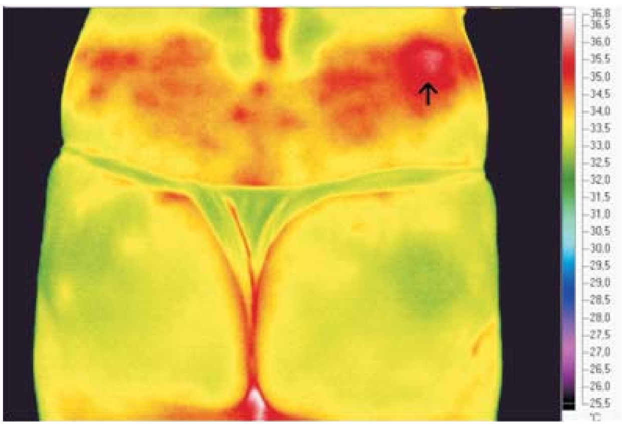


Figure 5.
↑ focal increased temperature activity posteriorly in the area of the crista iliaca on the right side

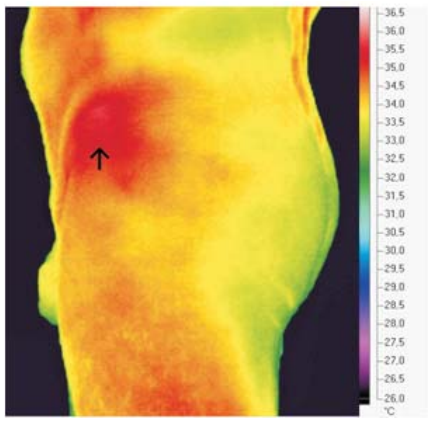


Figure 6.
↑focal increased temperature activity laterally in the region of the spina iliaca anterior superior

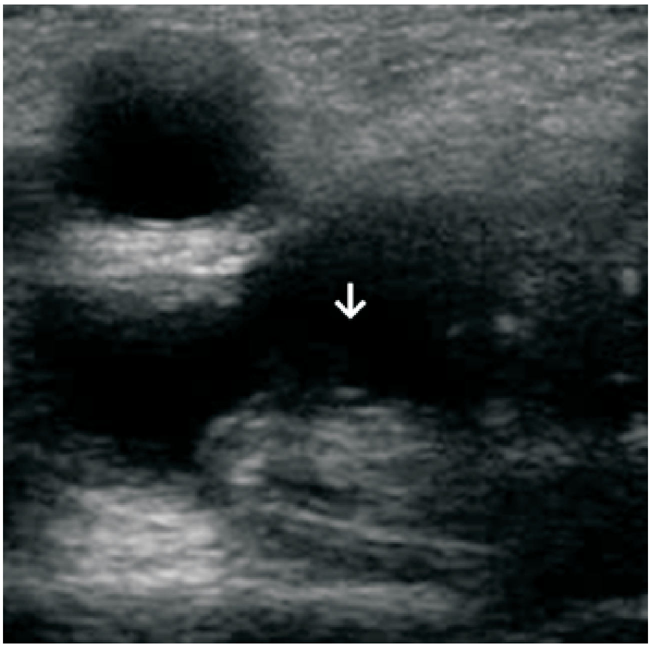


Figure 7.
Sono: hypoechoic filling bursa iliopectinea ↓

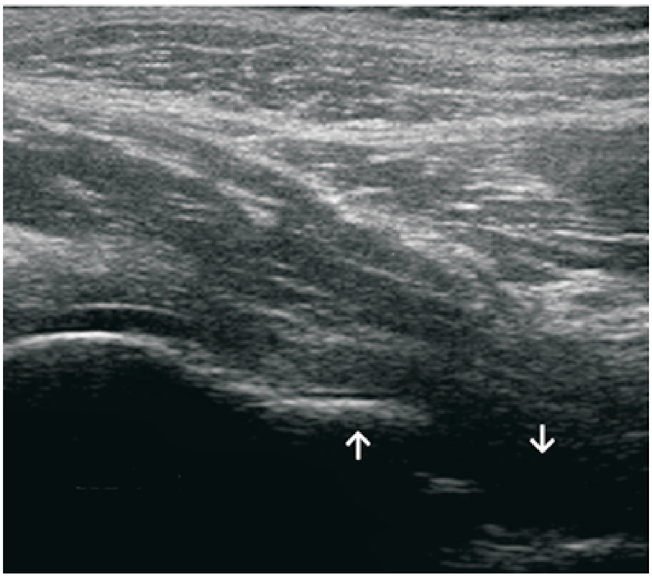


Figure 8.
hypoechoic filling ↓hydrops articularis and ↑osteophyte at the point of transition caput femoris to collum femoris

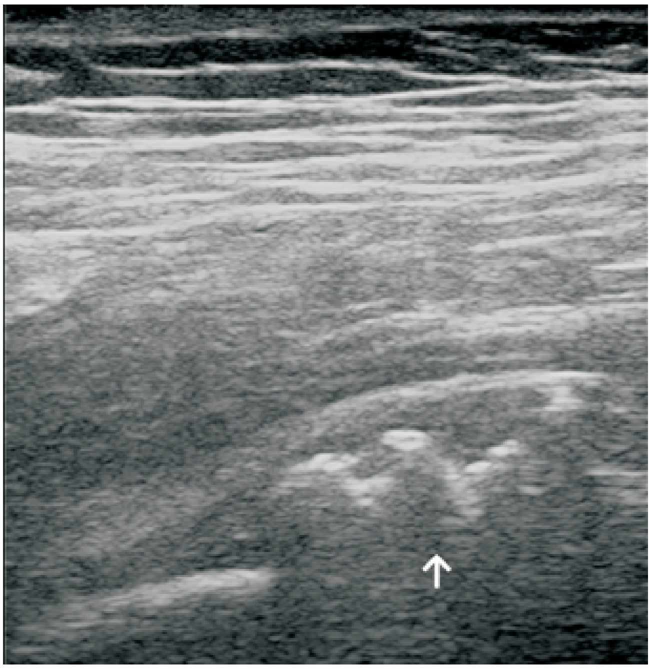


Figure 9
Sono: image of the head of the femur ↑at coxarthrosis IV.st

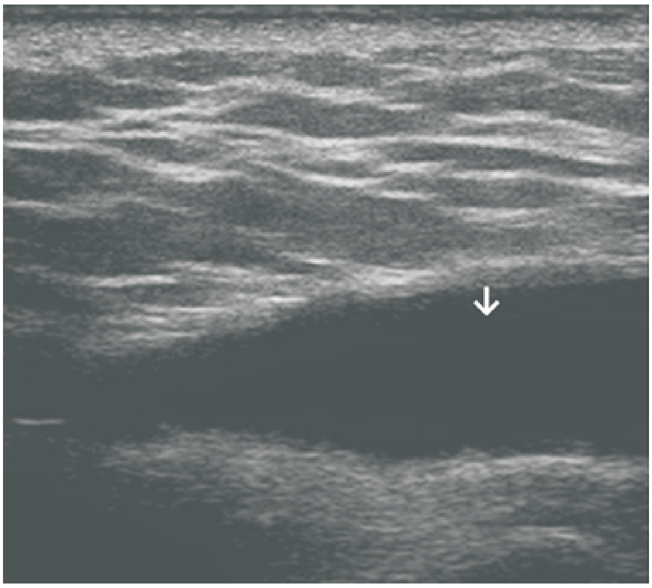


Figure 10.
Sono: hypoechoic filling bursae trochantericae

Discusion

The authors Krause and Novák assembled a group of 300 hip joints of subjects above 65 years of age. They found 43% of aging hip joints. One third of these patients reported subjective complaints. It is sometimes difficult to differentiate between the maximum changes typical of the aging hip joint and incipient arthrosis. Correct evaluation can be made only after prolonged follow-up of the patient [14]. Suresh states that osteoarthrosis was traditionally detected by X-ray examination. X-rays however have limited sensitivity for demonstration of the small changes of cartilage in the early stages of osteoarthrosis. MRI has a high ability to differentiate soft tissues, however its high cost and low availability limits its common usage. Daily routine use of arthroscopy is limited by its invasivity. Due to tremendous progress in ultrasound during the last 10 years we can better understand this disease and better evaluate the effect of treatment [15]. Ultrasound imaging can also detect minimal changes in soft tissues and joint effusion, which are not detectible by physical examination because of the deep location of the hip joint. Ultrasound guidance now also plays a significant role in reliable and safe execution of therapeutic interventions. [16]. Marcelis, Daenen, and Ferrara performed ultrasound examination of hip joints mainly for newborn hip joint dysplasia evaluation [17]. Due to the progress of device sensitivity, today we perform more hip joint examinations in adults [16]. Chhem and Cardinal published findings suggesting that pain from the hip joint could result from articular and periarticular structures. Ultrasound is suitable for examination of pathology of the surrounding soft structures and for examination of TEP complications. It is possible to distinguish solid mass from pseudomass and cystic lesions. However, it is supplementary to X-ray examination, because bone and intraarticular lessions could be underestimated by ultrasound. They recommend the use of ultrasound also for navigation during aspiration of joint filling and joint applications [18].

According to Ring and Ammer, infrared thermal imaging records the temperature distribution on the surface of the human, which may detect abnormalities in spatial and intensity distribution that are associated with defined diseases [19]. There are only a small number of articles dedicated to thermographic investigations of hip joint pain. Ryoichi Kanie used pre and post-operative thermographic measurement of osteoarthritis of the hip. The results show that the skin temperature of the gluteal region is lower on the diseased than on the healthy side, and, if both sides are diseased, the more seriously affected side has a lower temperature. In patients with unilateral disease, the temperature difference correlates with the grade of symptoms [20]. We can confirm these findings based on the results of our studies. In a previous study from 2013, we noted hypothermia in the gluteal region in a high percentage of cases (74.5%) in patients with significantly limited range of motion (ROM) in the hip joint [21]. Even in the currently presented study, there was a significantly greater number of hypothermic findings in the gluteal region in the case of coxarthrosis of a higher degree (III.-IV.grade), namely in 84% of such findings. Only 33% of patients with coxarthrosis of the I.-II.grade had a hypothermic finding. Ryoichi Kanie describes that in 20 surgical cases, the lowered temperature found before operation improved along with the relief of symptoms after operation. The temperature difference between both sides became smaller over time (20). This is consistent with the results of our study, where the number of hypothermic findings was reduced to 25% after TEP. Local circulatory insufficiency caused by gluteal muscular atrophy and shortening, and hip joint pain, which are the result of osteoarthritis of the hip, are thought to play a major role in the lowered temperature in the affected areas. The clinical application of thermographic examination to cases of osteoarthritis of the hip is considered to be of value in evaluating the progress of disease, deciding on appropriate treatment, and in follow-up evaluation (20).

Alves and co-workers evaluated the use of digital thermography in assessing treatment response in dogs with hip osteoarthritis (OA). They compared their results with an objective measure and two clinical metrology instruments. 100 hip joints of 50 police working dogs with bilateral osteoarthritis were examined in a randomized, double-blinded study. Digital thermography, mainly lateral T view evaluation, correlated with weight-bearing distribution, clinical metrology instrument scores, and the presence of caudolateral curvilinear osteophytes on the ventrodorsal view at the initial assessment. These findings are associated with the development of clinical symptoms of hip OA. Hypothermia was noted in the case of severe OA. But the differences were not statistically significant [22].

The application of laser spot thermography was used for damage detection in ceramic samples of hip joint implants with surface breaking cracks by 4 authors - Roemer, Pieczonka, Juszczy and Uhl. The technique is based on an external heat delivery to a test sample, by means of a laser pulse, and signal acquisition by an infrared camera. Obtained results are compared with reference measurements obtained with vibrothermography. Both techniques can be effectively used for damage detection and quality control applications of ceramic materials [23].

Fukahori´s team evaluated clinically 31 dogs with and without inflammation in the coxofemoral joint. The temperature registered by the thermograph in the lateral projection by patients with joint inflammation was significantly different from that of control animals without inflammation. The method showed a sensitivity of 80%, specificity of 87.5%, and accuracy of 83.87% [24].

Scheidt and co-workers performed a systematic online database search, based on the Cochrane, PICOT and PRISMA guidelines, and they retrieved 254 studies. All publications referring to thermographic examination in arthroplasty of the hip and knee were included. 249 of the studies were later excluded due to the defined inclusion and exclusion criteria, and so five studies with 251 patients were included finally in the evaluation process. The conclusion was that infrared thermography is a useful tool in the perioperative care of patients after arthroplasty of the knee and hip joint [25].

Kjær and co-workers investigated 56 total hip replacement patients for deep vein thrombosis using contact thermography and bilateral ascending phlebography. Examinations were performed on the 7th day after surgery. Phlebography discovered unilateral deep vein thrombosis in six patients. Two of them had corresponding findings at thermography. This means that thermographic examination gave four false negative results, and 14 false positive thermograms were also found. Contact thermography is of no value as a screening test for deep vein thrombosis following major hip surgery [26].

Bouffard and Goltz recommend the use of ultrasound in sport medicine for detection of musculoskeletal lesions which are occuring acutely or the result of likely overloads. Ultrasound visualizes extra- and intraarticular structures. The immediate receipt of data increases the possibility of early restoration of the patient into training. The advantage of ultrasound is the possibility of dynamic examination and the use of stress maneuvers. The causes of hip joint pain in power sports are often cortical tendon attachment avulsions, intratendineal ruptures, ruptures of labrum acetabuli, hip joint effusion, direct and indirect thigh traumas. These can be sonographically visualised as hypoechoic defects. Heterotopic ossifications could be displayed even earlier than radiologically. MRI is nonspecific in these cases: it shows just deviation in the hyperintensity of the signal. These recommendations correlate with the results of our study, where we noticed most of the extra-articular findingswere in athletes. Mobile ultrasound units allow the monitoring of athletes, and their training and match data can be stored on electronic storage media [27]. The use of ultrasound for the purpose of hip joint pain examination in sportsmen is recommended also by Jacobson. We can distinguish pain caused by joint disease from pathology of the tendons and muscles [28].

Conclusion

Coxarthrosis is considered to be the most common cause of hip joint pain. However, in a cohort collected in a private clinic over 12 years, coxarthrosis and complications after TEP explained only 36% cases of all hip joint pains. The rest are findings in extra-articular structures. Infrared imaging is highly sensitive in cases of high grade coxarthrosis, when the image of hypothermia can alert the physician to the morphological changes associated with aging in a timely manner. Its importance is also in monitoring changes in the temperature pattern after medical interventions. Evaluation of hip joint pain cause and their exact specification without the use of imaging methods is difficult.

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