Ethno Med, 12(3): 146-153 (2018)
DOI: 10.31901/24566772.2018/12.03.561

Advantages of the Ultrasound Study for the Diagnosis of Osteoarthritis in the Knee, Ankle and Foot

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KEYWORDS Cartilage. Degeneration. Joints. Osteoarthritis. Ultrasound

ABSTRACT Ultrasound in recent years has been shown to be a valuable study; however, it is necessary to carry out research that highlights the use of this method in order to identify predisposing factors for osteoarthritis, as well as to have a classification that allows determining the phase in which the disease is currently.The research proposes to determine the effectiveness of the ultrasound for the diagnosis and monitoring of osteoarthritis. The study was made non-experimental, cross-sectional, descriptive, evaluating 100 subjects in both lower limbs. The predisposing findings found were misalignment of the extensor mechanism and the presence of undiagnosed lesions. The damages most frequent related to osteoarthritis were: thinning and irregularity of articular cartilage and cortical bone, synovitis, marginal osteophytes; concluding that the technological advances in ultrasound allow to show initial degenerative changes and we can visualize predisposing factors for this condition.

INTRODUCTION

Osteoarthritis (OA) is a chronic degenerative joint disease, which has as its main characteristics, a degeneration progressive and loss of articular cartilage, subchondral bone, and involvement of synovial tissue, associated with changes in the peri-articular soft tissues (Mobasheri et al. 2017).With aging, the joint tissues are made less resistant to wear and begin to manifest as swelling, pain, and in many cases, loss of mobility of the joints. Changes occur in the soft tissues of the joints and the bones. This disease may correspond to a hereditary manifestation or inadequate habits during life.

Osteoarthritis is one of the diseases benefited in its diagnosis by technological advances. In particular, the ultrasound (US) is gaining ground between other diagnostic imaging techniques in the study of osteoarthritis. Due to the high resolution shown, it can detect minimal alterations in the three articular structures predominantly affected by osteoarthritis: articular cartilage, synovial membrane, and subchondral bone (Vlychou et al. 2009).

Cetina (2017) emphasizes that ultrasound allows the detection and quantification of joint effusion, the presence of thickening of the synovium and small bone erosions, although these cannot be visible by conventional radiography. He says that this means of diagnosis allows adequate evaluation of peri-articular and extra-articular structures such as tenosynovitis, calcifications, cysts, among others.

The research carried out by Podlipská et al. (2017) point that the sonographic study allows identify the changes in the structure of the articular cartilage in patients with osteoarthritis. In addition, they make reference to the relationship between these changes and the presence of accompanying clinical manifestations.

Acevedo et al. (2012) demonstrated in their study that before the appearance of clinical manifestations, internal modifications (changes of degenerative aspects in articular and per articular structures) were exposed in elderly patients.

Unfortunately, despite technological advances in imaging and its use in the diagnosis and follow-up of conditions such as osteoarthritis, the researchers believe it is necessary to carry out research to evaluate the applicability of the sonographic study in the identification of initial

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osteoarthritic changes or factors that predispose to the degeneration of the peri-articular structures of the knee, ankle and foot. In the same way, the researchers think that a classification of osteoarthritis should be considered from the sonographic point of view. This has led researchers to arrive at the following objectives:

General Objective

- determine the effectiveness of the ultrasound study for the diagnosis of osteoarthritis in knee, ankle and foot.

Specific Objectives

- Identify factor predisposing degenerative changes peri-articular, in the knee, ankle, and foot.
- Determine the changes in the ultrasound pattern related to osteoarthritis in the knee, foot and ankle in workers at the University of Tarapacá.
- Carry out a classification of osteoarthritis, taking into account the changes in the ultrasound pattern found in the study.

METHODOLOGY

A quantitative, non-experimental, cross-sectional study with exploratory analysis of variables was carried out.

Sample Selection

An intentional sample was considered based on inclusion and exclusion criteria. A population of 200 subjects who voluntarily attended the Sciences Department of Physical Activity and Sport of the University of Tarapaca during April to June 2017 was defined.

The sample consisted of 100 subjects who met the inclusion and exclusion criteria proposed in the present investigation. With ages older than 40 years 32 males and 68 females, of them 20 academics, 70 officials and 10 administrative staff, these had an educational level: basic 2, technical superior 47 and 49 university graduates. The studies were carried out bilaterally for a total of 200 knees, 200 ankles and 200 feet.

Inclusion Criterion

- That they were over 40 years of age and that they work as civil servants, academic or administrative of the University of Tarapacá, Arica.
- That they go to the study and sign the informed consent that approves their voluntary participation in the study.

Exclusion Criterion

- The presence of degenerative articular disease, implants in the joints objects of studies, surgical history concerning degenerative joint disease.
- They express desire not to participate in the study.

Methodology Used

The ultrasound study was based on the methodology suggested by Valls et al. (2003) in Ultrasound of the locomotor system.

Elements Taken into Account

Predisposing Ultrasound Factors

Osteoarthritis has predisposing factors such as age, family history, overweight, obesity, malnutrition, systemic diseases, genetic factors, overuse, and trauma, use of inadequate shoes, musculoskeletal system alterations such as scoliosis, asymmetries in the lower limbs, muscular imbalances, among others(Subervier 2017). However, researchers' they considered those that were found through ultrasound evaluation such as maladjustment of the extensor mechanism, the presence of sesamoid bones, abnormal joint mobility and old lesions not previously diagnosed (sprain, fractures).

Incipient Ultrasound Abnormalities

As incipient, these were contemplated: irregularity of articular cartilage, widening or exudate of articular cartilage and fine tuning of the articular cartilage. The presence of calcifications also been considered although they are caused by multiple alterations such as micro-trauma, mechanical overload and aging of tissues with decreased blood flow, etc.

Diagnosis and Ultrasound Classification of Osteoarthritis

For the diagnosis and classification of osteoarthritis the presence of insipient alterations

adding to it were considered: the presence of thickening of the synovium with cellular elements in the interior. The irregularity of the articular cartilage, irregularity of the cortical bone, impingement of the joint space, osteophytes, chondrophytes, free intra-articular bodies, bone fragments, nodules and presence of cysts were also considered.

Equipment Used

SunBright brand ultrasound, made in China, using multifrequential linear transducer, stretcher, ultrasound gel, data collection and computer worksheets.

Aspects Bioethics

The researchers certify that all patients signed the consent to participate in this investigation, accepting the publication of ultrasound images that do not allow patient identification. This research was approved by the Ethics Committee of the University and had institutional support.

Data Analysis

A computerized analysis of all the data collected was carried out using SPSS 21 software. Nominal variables such as age, sex and weight, were taken into account.

Conceptual variables: Concept of osteoarthritis, knowledge regarding degenerative changes, application of ultrasound in the musculoskeletal system.

Descriptive statistics methods for each of the studied variables was included: Absolute (n), percentage (%), Mean (X) and Standard Deviation (DE), depending on the type of data processed.

RESULTS

In the present study, general data wascollected concerning the personal pathological antecedents of the subjects under study. Table 1 underlines a high incidence of workers at the Universidad de Tarapacá who lead a sedentary life reflected in 61 subjects. On the other hand, there is a history of pain or discomfort in other articular planes such as shoulder, hands, hip, and neck. In a total of 55 subjects, and of the 100 workers evaluated 44 are obese, and 36 are overweight, factors that can adversely affect the occurrence of osteoarthritis.

Table 1: Personal pathological history

Personal pathological history	*No.*	*Findings*
Arterial Hypertension	100	29
Type I Diabetes Mellitus	100	1
Diabetes Mellitus Type II	100	5
Hyperthyroidism	100	5
Hypothyroidism	100	15
Other Cardiopathies	100	2
Obesity	100	44
Overweight	100	36
Painful Manifestations of SOMA, Not Including Pains in the Knee, Ankle and Feet	100	55
Increased Volume in SOMA without including Knee, Ankle and Foot Pains	100	5
Sedentary	100	61
Other Diseases	100	9

In relation to the predisposing findings of osteoarthritis, the misalignment of the extensor mechanism, with a total of 82 affections, 45 in the right leg and 37 left were found. The misalignment of the extensor mechanism leads to inadequate gait biomechanics, causing a poor distribution of body weight, which favors the wear of the articular cartilage in loading areas. As a second finding, they visualized the previous lesions undiagnosed, with a total of 28 lesions distributed in both knees, ankles, and feet, with a greater incidence at the ankle level with 17 findings (Table 2).

The alterations in the ultrasound pattern characteristics of osteoarthritis in knee, are represented in Table 3, where a high incidence

Table 2: Predisposing factors of osteoarthritis (ultrasound findings) of the knee, ankle and foot

Predisposing factors	*Knees*		*Ankle*		*Foot*	
	R	*L*	*R*	*L*	*R*	*L*
Expansion Mechanism Malalignment	45	37	0	0	0	0
Undiagnosed Old Lesions (Sprain, Fractures)	5	3	10	7	3	0
Presence of Sesamoid Bones	2	2	0	0	2	2

of thinning of the medial articular cartilage can be seen with 111 findings. Followed by thinning of the lateral articular cartilage with 68 observed, at this point, it is necessary to point out that areas of loads have a greater predisposition to the incipient deterioration, which is previously manifested with enlargement or exudate, which is subsequently refined because of the degenerative deterioration of articular cartilage.

Table 3: Diagnosis of alterations in the ultrasound pattern of knees

Alterations in the ultrasound pattern of knees	*N*	*Ultrasound findings*
Synovitis	200	43
Thickening of the Synovial	200	5
Synovial Thickening with Cellular Elements	200	6
Thinning of Medial Articular Cartilage	200	111
Lateral Articular Cartilage Refinement	200	72
Irregular Articular Cartilage	200	46
Thinning of the Joint Space	200	5
Osteochondrophytes	200	7
Marginal Osteophytes	200	63
Intra-articular Calcifications	200	4
Intra-articular Free Bodies	200	2
Popliteal Cyst	200	1

In the same way, it was possible to verify the presence of marginal osteophytes, which were found in different phases (incipient, to large osteophytes that prevented visually access to the intra-articular environment by the closure they produce at the level of the joint space, these large osteophytes, in the osteoarthritic phase 4, resemble the image of ice cream cone).

In the present study, the researchers verified the presence of 63 knees with marginal osteophytes, distributed 38 in the right knee and 31 in the left; the irregularity of articular cartilage followed by synovitis could be visualized in a total of 46 and 43 respectively. Figure 1 shows the ultrasound study of a 60-year-old female subject with osteophytes at the medial compartment of the right knee.

Through the sonographic analysis it was possible to detail in the incidence of degenerative affections at the ankle level, verifying the presence of 17 findings of intra-articular calcifications and thinning del cartilage articular (Table 4).

When evaluating the changes in the ultrasound present at both feet, major incidence of intraarticular calcifications with 50 findings followed by thinning of the articular cartilage at

Fig. 1. Ultrasound findings, presence of osteophytes at the level of the medial compartment of the right knee. 60 year old female patient

Table 4: Diagnosis of alterations in the ultrasound pattern of ankle

Alterations in the ultrasound pattern of ankle	*N*	*Ultrasound findings*
Synovitis	200	5
Medial Articular Cartilage Securing	200	9
Lateral Articular Cartilage Refinement	200	7
Articular Cartilage Irregularity	200	8
Intra-articular Calcifications	200	17

the level of the astragalus - scaphoid with a total of 47 manifestations, distributed 27 in the right foot and 20 in the left was observed. The narrowing at the level of the cuneiform - scaphoid cartilage was visualized in a total of 27 that were distributed 15 in the right foot and 12 in the left. Synovitis was the smallest finding, only visualized in a subject at the right foot level (Table 5).

Figure 2 show the ultrasound findings present in a 53-year-old woman on the right foot level, observing the presence of irregularity of the cortical bone and thinning of the articular space in the astragalus-scaphoid and scaphoid cuneiform.

Table 5: Diagnosis of alterations in the ultrasound pattern of foot

Alterations in the ultrasound pattern of foot	*N*	*Ultrasound findings*
Thinning of the articular cartilage Scaphoid Astragalus	200	47
Cuneiform Scaphoid Articular Cartilage Refinement	200	27
Bone Cortical Irregularity	200	17
Thinning of the joint space	200	7
Marginal Osteophytes	200	2
Intra-articular Calcifications	200	50
Etherotopic Calcifications	200	18
Intra-articular Free Bodies	200	3
Bone Fragmentation	200	3
Nodules	200	2
Distension Joint Capsule	200	1
Hallux Valgus	200	18

In the present study, 190 osteoarthritis findings were found, which manifested in greater proportion at the knee level with 95, followed by feet with 84 and finally ankle with 11 affections (Table 6).

The bilateral echography study of 100 subjects allowed the researchers to visualize the incidences of changes in the ultrasound pattern

Fig. 2. Ultrasound findings, presence of irregularity of the cortical bone and thinning of the articular space in the scaphoid talus articulation and cuneiform scaphoid. 53 year old female patient. Rightfoot

Table 6: Incidence of the osteoarthritis according to the ultrasound findings

Grade	*Knee*			*Ankle*			*Foot*			*Total*
	Right	*Left*	*Total*	*Right*	*Left*	*Total*	*Right*	*Left*	*Total*	
Grade 1	20	22	42	5	6	11	26	21	47	100
Grade 2	18	20	38	0	0	0	21	15	36	74
Grade 3	9	5	14	0	0	0	1	0	1	15
Grade 4	0	1	1	0	0	0	0	0		1
Total	47	48	95	5	6	11	48	36	84	190

in previous, incipient and advanced stages of osteoarthritis in the lower limbs, which let them to describe the findings and to relate them to the level of joint deterioration to propose an ultrasound classification of osteoarthritis.

The degree of deterioration of the articular cartilage, the characteristics of the joint effusion, the integrity of the cortical bone, the thinning of the joint space, the presence of osteophytes, bone fragments, popliteal cyst, among others, were examined considering its magnitude, characteristics, and coexistence in the findings. As a criterion for the classification of osteoarthritis, the researchers decided to base themselves on the radiological classification performed by Kellgren and Lawrence (1957) which establishes 5 degrees of classification, making the same modification depending on the echographic assessment, according to the researchers of the present study (Table 7).

DISCUSSION

The results confirm what is mentioned by Cisneros et al. (2015) that the early detection of degenerative joint disease can be evidenced by ultrasound study. Highlighting that these studies should be performed on the elderly to determine precociously alterations caused by the wear of the osteo joint system; a criterion that is shared by the researchers of the present study.

For its part Guinsburg et al. (2013)emphasize that ultrasound has been shown to be a very sensitive and useful tool for the detection of alterations presented in the intra and periarticular soft tissues. Such alteration includes synovial hypertrophy, the synovial cysts, the subchondral bone and the presence of osteophytes, which was verified in the research.

Likewise, Mathiessen and Conaghan (2017) raises that in the osteoarthritis the synovium may show significant changes, even before visible cartilage degeneration has occurred, with infiltration of mononuclear cells, thickening of the synovial lining layer and production of inflammatory cytokines, highlighting that morphological changes can be visualized by imaging studies including ultrasound.

According to Mariano et al. (2016), the bone cortex is easily recognized by ultrasound as a regular hyperechoic line, placed in the depth of the soft tissues, emphasizing, furthermore, that in the presence of irregularities, destructions or eventual alterations, its commitment should be

Table 7: Ultrasound classification of osteoarthritis of the knee, according to the researchers of the present study

Grade 0	No alterations in the ultrasound pattern
Grade 1	Slight irregularity of articular cartilage, widening or exudate of articular cartilage, insipid osteophytes, may or may not exist synovitis.
Grade 2	Moderate irregularity of the articular cartilage, with a presence of thinning in areas of load, presence of chondrocytes, small calcifications and osteophytes of easy visibility ultrasound. There may or may not be synovitis.
Grade 3	Severe irregularity of the articular cartilage, narrowing of the articular space, marked thinning of the articular cartilage the presence of intra articular calcifications, presence of multiple marginal osteophytes, irregularity of the cortical bone, can be visualized synovitis with the presence of cellularity inside and popliteal cyst may be seen.
Grade 4	Marked deterioration of the articular cartilage, severe sclerosis, hardly requires joint space, presence of multiple per articular and intra articular calcifications that may be large, the joint capsule may be increased, osteophytes that cause almost total closure of joint space (in cone-shaped ice cream), bone deformities, chronic-appearing synovitis with multiple cellularity in its interior that impresses an increase in its thickness, can visualize thickening of the synovial and presence of popliteal cyst.

suspected. Based on the above, the researchers of the present investigation consider that the structure of the bone cortex should be a factor to be considered among the elements that can be found in the stages prior to the appearance of osteoarthritis.

In the present study, it was possible to demonstrate that in spite of the absence of clinical manifestations in relation to the presence of osteoarthritis, they may show changes in the normal sonographic pattern. This confirms that there is no direct correlation between the degree of deterioration of the joint, from the sonographic point of view, and the presence of clinical manifestations. This criterion coincides with that issued by Adams et al. (2012), who emphasize that the presence of clinical signs in relation to osteoarthritis is not directly related to the radiological findings.

Keen et al. (2008) and Saarakkala et al. (2012), emphasize in their research that the ultrasound of the joint system in the coming years can become an imaging technique of choice for the initial study of osteoarthritis since it is a tool that allows the understanding of the pathophysiology of the disease, identify the painful structure and keeps track of the different structural changes, especially cartilage lesions in early stages.

CONCLUSION

The technological advances in ultrasound allow us to detect the predisposing factors of osteoarthritis, as well as degenerative changes in their initial stages. Among predisposing factors, showed a high incidence in the misalignment of the extensor mechanism, which predisposes to variations in the biomechanics of the movements and can exert an accelerating effect of the degeneration proper to osteoarthritis.

As a result of the current investigation, it is possible to propose an ultrasound classification for osteoarthritis of the knee. The characteristics of the findings, stage of onset, relation to other ultrasound signs, were taken into account. All the aforementioned will simplify the process for studies to come.

Diagnosis before the appearance of clinical symptoms would lead to adjustments in lifestyle, to prevent deterioration of anatomical structures and the appearance of accompanying symptoms of osteoarthritis, which may have a marked influence on the quality of life of the subject.

RECOMMENDATIONS

The researchers suggest carrying out longitudinal investigations, with a larger sample. In the same way, the researchers recommend that studies focused on the diagnosis and monitoring of osteoarthritis be carried out using other imaging means. They encourage the execution of other investigations focused on the relationship between echography findings and the presence of clinical manifestations.

ACKNOWLEDGMENETS

This research has been funded as part of the project of the Major Project in Scientific and Technological Research UTA 2016. Code 5751-16.

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Paper received for publication on January 2018
Paper accepted for publication on March 2018