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Current evaluation of sonography of the meniscus

Results of a comparative study of sonographic and arthroscopic findings

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Summary. Sonography of the knee has gained in significance in the diagnosis of the meniscus; experimental and clinical studies have demonstrated that the normal and pathological anatomy of the meniscus can be visualized on a sonogram. The aim of this comparative investigation is to evaluate sonographic lesion diagnosis in comparison with arthroscopic findings, using a standardized examination method. Two hundred and six knee joints were first scanned sonographically using a 7.5 MHz sector transducer. The examining doctor had neither anamnestic nor clinical information in advance. On the following day, the joints were examined arthroscopically, without the findings of the day before being available to the examiner. When the findings were compared, the sensitivity of sonographic diagnosis of lesions was found to be 82.2% and its specificity 87.6%. The patients were of varying ages and had varying anamneses. The results show that sonography of the meniscus is a valuable diagnostic help when the knee-joint symptoms are not clear, given that the correct technical equipment and sufficient experience with this form of examination are at hand. The advantage of sonography is that, in contrast to arthroscopy, it is noninvasive and easily available.

In the past few years, sonographic diagnosis of lesions of the meniscus has been gaining in significance [1, 6, 12–15]. The disadvantage of arthrography and arthroscopy, the diagnostic possibilities previously available, is that they are invasive [4, 5]. However, they often have to be used, since knee disorders cannot always be clearly identified by clinical examination.

As early as 1980, Dragonat and Claussen [3] tried to visualize the meniscus with a 5-MHz compound scan. They felt this method showed little promise for clinical use because the scan picture was inhomogeneous. Similarly, Sattler and Gerhold reported in 1984 [8] that the meniscus did not show up clearly when they examined the knee with a 4-MHz real-time sector scan. In 1986, Selby et al. [10] examined a number of patients and found that they could get a clear image of the posterior horn of the meniscus when using a 5-MHz linear transducer, but that the pars intermedia and anterior horn did not show up satisfactorily on the sonogram. The same team carried out experimental examinations of cadaver knees [11] and established that all kinds of meniscus tears could be visualized sonographically: longitudinal lesions as small as 2 mm in length, but radial lesions only 5 mm and longer.

It was not until 1987 that the experimental and clinical investigations carried out by Sohn et al. with a 7.5-MHz sector transducer demonstrated that the pars intermedia and the anterior horn of the meniscus would show up on a sonogram and that lesions and degeneration could be diagnosed [12, 13]. After numerous comparative studies of sonography, arthrography, and arthroscopy had been made and surgical findings taken into account, the reliability of sonography of the meniscus was confirmed, given that the technical requirements were fulfilled and the examining doctor was sufficiently experienced [14].

Having carried out sonographic diagnosis of lesions of the meniscus in our department for more than 2 years, we decided to compare sonographic and arthroscopic findings in order to judge accurately how reliable the diagnosis of lesions of the meniscus is at present.

Methods

Case studies

In the period between November 1987 and July 1988, 206 patients (73 female and 133 male) were admitted to our department for arthroscopy. The affected knee was scanned the evening before the arthroscopic examination. The average age of these patients was 36.2 years, with every age-group between 11 and 72 years represented: the largest age-group was composed of those between 30 and 39 (36%). Most of the patients said their knees had been giv-

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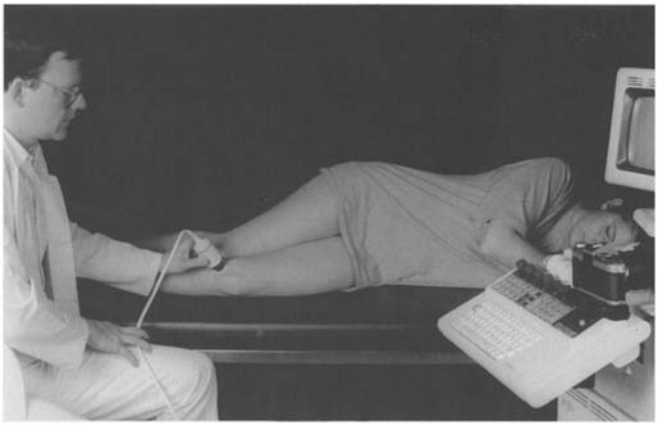


Fig. 1. Sonographic examination of the meniscus. Here: pars intermedia of the inner meniscus, left

ing them trouble for more than 6 weeks, and only 64% could remember some injury. The clinical, sonographic, and arthroscopic examinations were carried out by different doctors who wrote down their findings independently of each other on special record sheets. This meant that they could later evaluate each set of results without knowing the results of the other examinations. Of the patients, 9.2% had already had arthrography done in another hospital, but the findings were not taken into statistical account since the number of cases was so small.

We used the 7.5-MHz frequency of the Access TM 10-multifrequency transducer "Ultramark 4" made by ATL. The transducer had a 6.4-cm crystal and a focal point of 2.1 cm. An aqua pad was not used.

Examination procedure

In the *clinical* examination, particular attention was paid to the known signs of meniscus trouble, and a detailed case history was taken. *Arthroscopy* was carried out in the usual way with the patient under general anaesthetic. It was performed by an experienced operator, and the examination was filmed on video.

The *sonographic examination* was carried out according to the known standard technique [14]. After enough contact gel has been applied, the spherical sector-scanning head is placed on the hollow of the knee. It is important that the head remain vertical to the skin throughout the examination. First of all, it is recommended that a hypoechoic image of the popliteal artery and vein be visualized across the whole screen section in order to check the exact longitudinal position of the transducer. With the transducer held thus, the posterior joint cavity is scanned, first from its paramedian side. On a sonogram it is characterized by the semicircular contour of the femoral condyle and the angular outline of the tibia plateau. The meniscus should appear between them as a hypoechoic triangle, exactly in the center of the picture. By moving the transducer a little medially and laterally, the posterior horn of the inner and outer meniscus can be carefully assessed.

Next, the patient is asked to lie on his side with the knee being examined on top, bent at an angle of 20°. The transducer is moved slowly over the joint cavity, still held in its longitudinal position, and now the smaller pars intermedia becomes visible. The anterior horn is examined from the ventral parapatellar side, and with the knee bent at various angles between 60° and 90°.

Standard plane and recording

The exact longitudinal section of the knee joint has proved to be the best standard plane: the joint cavity appears in the center of the picture with clear outlines of the adjacent bony parts of the tibia and femur. It is also necessary to have an image of the meniscus triangle from its base to its tip, with its inner structure becoming visible. Once each section of the meniscus has been successfully scanned, sonographic examination ends with the transducer being slightly tilted on the spot ("looking round") and the knee being slowly bent and stretched and rotated (dynamic examination). At least one picture of each part of the meniscus was recorded in the standard plane (see above): posterior horn, pars intermedia, and anterior horn. Pathological findings such as tears, degeneration, loose fragments, or osteochondrotic areas were recorded on separate sonograms.

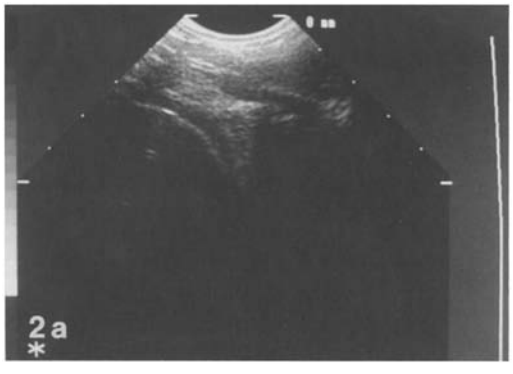
We used a multiformat camera (Agfa Skopix) to record the images, because such a camera has excellent picture quality. The film was best divided into six sections for each knee. In selected cases, a video film gave us a complete record of the examination process.

Criteria of sonograpic findings

The scanner was adjusted so that the meniscus appeared entirely as a hypoechoic, pale gray, homogeneous image. Only light flecks or lines which stood out clearly in marked contrast to the hypoechoic meniscus and which could be followed in a number of sectional planes were interpreted as lesions. Areas of the meniscus that were blurred or cloudy and had a good echo reflection were judged to be centers of degeneration, and images of intra-articular parts that did not belong to the meniscus (such as cruciate ligaments or loose fragments) were not taken into consideration when the meniscus was assessed.

Results

According to the arthroscopic findings, 101 (49%) knee joints had a lesion of the meniscus; cartilage changes, plical hypertrophy, loose fragments, and chondrocal-



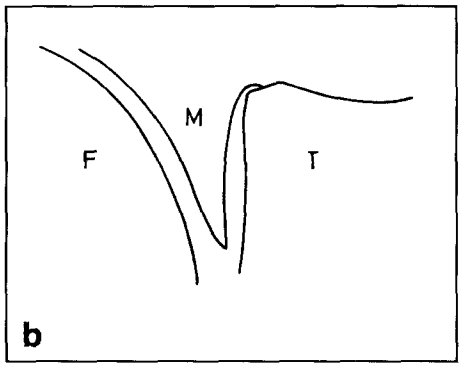


Fig. 2a, b. Normal findings of the posterior horn of the meniscus, sonographically recorded. Standard longitudinal section shows the homogeneous triangular image of the meniscus, clearly distinguishable from the adjacent bone contours: *left,* femur *(F); right,* tibia margin *(T).* The capsular ligaments stand out distinctly at the base of the meniscus *(M)*

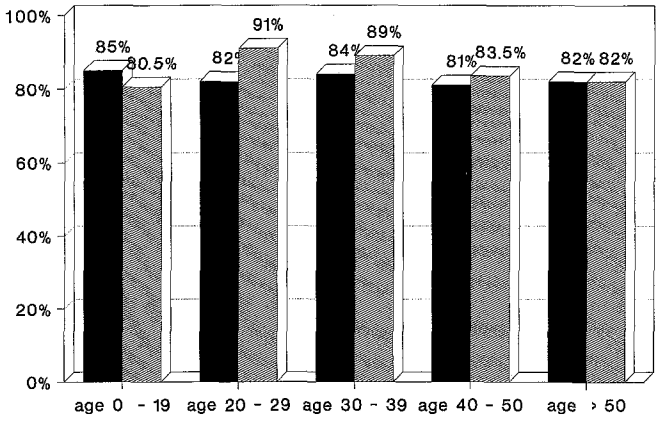


Fig. 3. Graph showing distribution of sensitivity and specificity of sonography of the meniscus in the various age-groups. ■, specificity; ▨, sensitivity

cinosis were detected in the other knees. Most of the torn menisci were found in the right knee (61.4%; left, 38.6%), affecting the inner meniscus in 84 cases and the outer meniscus in 19 cases. Two knee joints even had both inner and outer meniscus lesions. By far, the majority of lesions were located in the posterior horn (78%), and the most common kinds of tears were lengthwise and bucket-handle tears (65%).

In the clinical examination, positive signs of meniscus trouble were detected in 53% of the cases where arthroscopy had detected torn menisci; 15% presented uncertain findings, and there were no signs of a lesion in 32%.

A torn meniscus was diagnosed in 83 (40.3%) of the 206 knee joints by both sonography and arthroscopy; both methods ruled out a lesion in 92 (44.7%) cases. The remaining 31 (15%) cases where the findings did not agree have to be ascribed to faulty diagnosis by sonography. In 18 cases, sonography revealed negative findings but arthroscopy revealed positive findings; in 13 cases, sonographic findings were positive but arthroscopic findings were negative. These results correspond to an ultrasound sensitivity of 82.2% and a specificity of 87.6%.

When a closer look was taken at the relation of the sonographic results to the age of the patients – divided into the age-groups 0–19, 20–29, 30–39, 40–50 and older than 50 – there was no significant difference between the age-groups. There was also no significant divergence of results between the first and second half of our study.

The faulty sonographic diagnoses were analyzed: the 18 cases that had false-negative findings included six older tears in a center of degeneration, four bucket-handle tears, two horizontal tears, two tears near the base, and four lesions in the outer meniscus.

The 13 cases that had false-positive findings were shown by arthroscopy to be four degeneration zones, four regenerated menisci, three plicae alares, and two partly ruptured anterior cruciate ligaments.

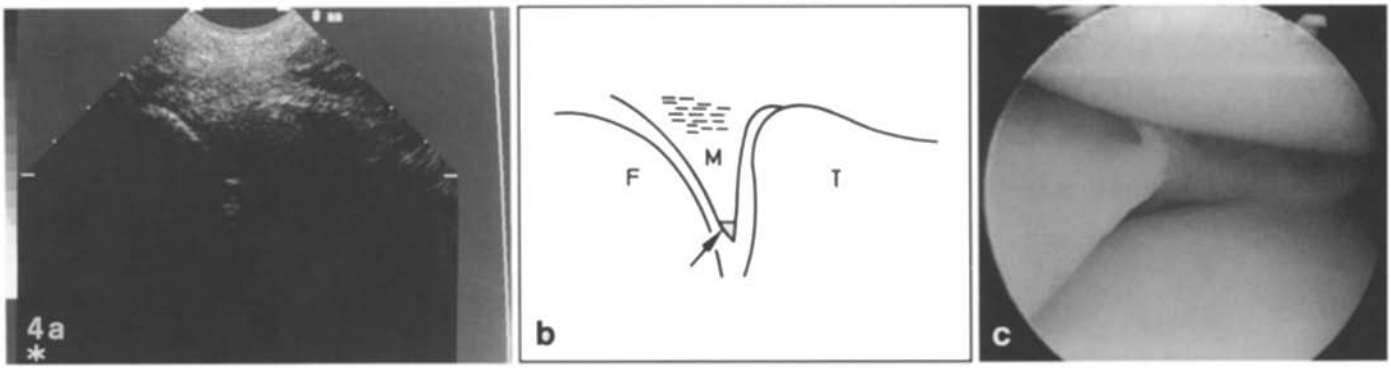
Discussion

The results of this study confirm that a high percentage of lesions of the meniscus can be recorded on a sonogram (82%) or excluded by it (87%). Sohn's high success rate [12, 13] could not be achieved, but we have to take into account that most of our cases were patients with chronic knee trouble and of varying ages. This also explains the main source of error, i.e.,misinterpreting older tears; because they usually also have marginal zones of degeneration, they frequently produce an unclearly defined reflected image which makes it difficult to distinguish from a pure center of degeneration.

Chronic knee trouble is difficult to assess by clinical examination: this is reflected in the relatively bad result of only 53% absolutely correct diagnoses. On the other hand, it was surprising that sonography of the meniscus did not reveal any significant differences between age-groups. If we disregard osteoarthritis of the knee, which is seldom an indication for arthroscopy and was therefore not included in this study, then sonography of the meniscus is equally suitable for every age-group. The best results were in the 20- to 40-year age range, with sonography achieving 82%–91% success and clinical examination 70%, although we have to take the higher incidence of fresh lesions into account.

Unexpectedly, it was the long tears, such as bucket-handle tears, that caused diagnostic difficulty in sonography. These were, without exception, dislodged bucket-handle tears whose reflected images were found a

Fig. 4a–c. Fresh tear in the tip, in the posterior horn/pars intermedia area of the inner meniscus. A pale line shows up at the tip of the triangle on the sonogram (**a, b**). *F*, femur; *T*, tibia; *M*, meniscus. Arthroscopic diagram (**c**) of a flap-like tear at the tip



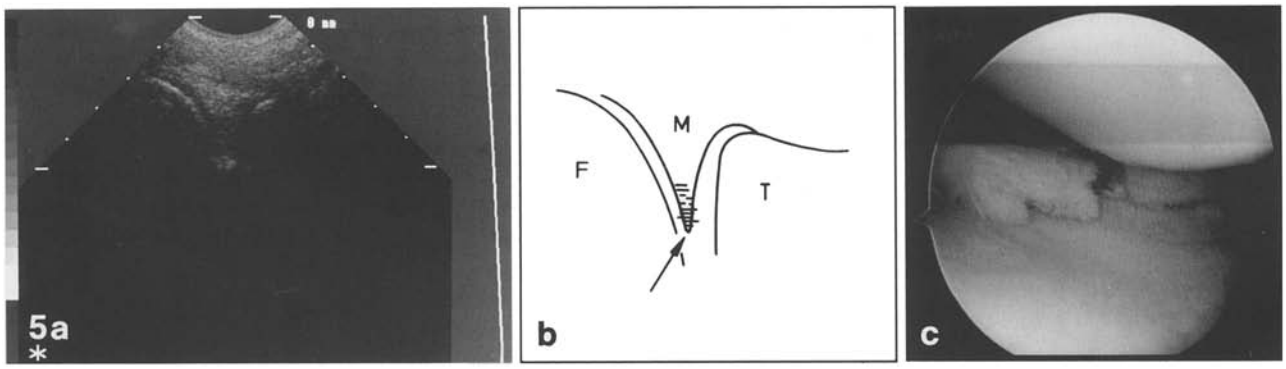


Fig. 5a–c. Old lesion at the tip of the inner meniscus posterior horn. The reflected image is not as strong or as distinct as that of a fresh lesion. It is surrounded by degeneration (**a, b**), as can be confirmed arthroscopically (**c**). *F*, femur; *T*, tibia; *M*, meniscus

long way to the medial side of the normal meniscus area and which were therefore not seen as lesions of the meniscus. Experimental and clinical examinations [2] revealed that if dislodged bucket-handle tears were carefully scanned, two reflected images should be expected as a rule – i.e., at the medial and lateral edges of the rupture – because of the gap between the base of the meniscus and the medial fragment. If this double outline is detected during the dynamic examination, it should be assessed as a sign of a bucket-handle or flap tear.

The faulty sonographic diagnosis of two horizontal tears can be explained: it is difficult to visualize this form of lesion because there is an insufficient area to reflect the ultrasound, especially if it is a small lesion of < 5 mm [11]. Lesions near the base of the meniscus can easily be overlooked because the joint capsule reflects a strong signal. The fact that four tears in the outer meniscus remained undetected is due less to the difficult conditions for examination in the outer knee-joint cavity than to poor observation on the part of the examining doctor, since lesions of the meniscus rarely occur in this area. Regenerated menisci are also problematic for sonographic diagnosis, because their fibrous tissue structure reflects a stronger signal than the fibrous cartilage of the meniscus and can therefore lead to misinterpretation. False-positive findings as a result of floating cruciate fibers or hypertrophic plicae should be avoidable with the aid of dynamic examination.

Bauer et al. [1] reported similarly good results. They had the same technical conditions for their examinations and applied the known criteria for lesions of the meniscus [14]. The critical attitude that earlier examining doctors had toward sonography of the meniscus must first and foremost be attributed to the inadequate technology of their equipment [3, 8].

A 7.5-MHz sector transducer has a wide sound-wave propagation, which is a great advantage in distinguishing the meniscus from the surrounding bone structures and in avoiding artifacts in the joint cavity [14]. Because discrete changes occur in meniscus tissue, there must be a balance of frequency, size of crystal, and focal zone [15], as we demonstrated in our own experimental studies [2]. Recently, there has been increasing agreement about the use of a 7.5-MHz sector transducer and the sonographic criterium of a torn meniscus as a structure that will reflect a strong signal [1, 6, 12–14].

Cautious statements [6] can be attributed, on the one hand to the technical problems with equipment, as mentioned above, or, on the other hand, to artifacts caused by the physics of ultrasound and anatomical delineation difficulties, e.g., of the Hoffa fatty pad, of the popliteal tendon, and of the joint capsule. Restrictions such as these can be overcome with the help of a dynamic examination technique.

With the results presented above, sonography of the meniscus is as meaningful as arthrography. Since ultrasound is non-invasive and easy to operate, sonography of the meniscus ought to be preferable to arthrography for the experienced operator. Compared with other methods of sectional imaging, especially MRI [7, 9], sonography is clearly cheaper and more easily available. Particularly in the case of chronic knee trouble with unclear clinical symptoms, a simple method of imaging such as ultrasound examination of the knee joint is proving to be a big help in further diagnosis.

However, there are sources of error in sonography of the meniscus which should not be underestimated, and even though these results were good, the wider clinical use of this method should remain limited to the experienced operator who constantly checks his results by arthroscopy until we have clarified the origin of artifacts and how to avoid them.

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