Surg Radiol Anat (2012) 34:31–38
DOI 10.1007/s00276-011-0829-3

ORIGINAL ARTICLE

The retinacula of Weitbrecht in the adult hip

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Received: 12 February 2011 / Accepted: 12 May 2011 / Published online: 27 May 2011

Abstract
Purpose The aim of the study was to describe the retinacula of Weitbrecht in the adult hip.
Materials and methods Specimens were obtained from 30 adult hips, average age was 77 years (age range 43–91 years), 8 specimens were fixed by formalin solution and 22 were not fixed.
Results Anterior retinaculum was found in 40% of examined specimens. The anterior retinaculum was in 83% of cases formed by a flat plate and in 17% by two to three parallel bands. Medial retinaculum was present constantly, extending from the attachment of the articular capsule at the base of the lesser trochanter towards the fovea capitis femoris as far as the edge of the articular cartilage. Typically, the retinaculum had the form of an inverted "T". Of the three retinacula, the medial one was the strongest. Lateral retinaculum was also present constantly. In 89% of cases, it had the form of a quadrilateral plate adjacent to the upper surface of the femoral neck. This plate arises from the insertion of the articular capsule on the upper part of the femoral neck at the base of the greater trochanter close to the trochanteric fossa. The plate extended along the upper edge of the femoral neck as far as the edge of the articular cartilage. Microscopic examination revealed fine blood vessels running through the retinacula.
Conclusion Lateral retinaculum and medial retinaculum are constant synovial plicae in terms of both occurrence and localization. Nutritive arteries run through both the plicae to supply the femoral head.

Keywords Retinacula of Weitbrecht · Blood supply of the hip joint · Synovial folds · Retinacular arteries

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Introduction

Intraarticular synovial plicae of the hip passing along the femoral neck were for the first time described by Weitbrecht [28] in 1742 (Fig. 1). In 1856, Henle [14] called these plicae the retinacula. This term was taken over by other authors and since the turn of 20th century the plicae have been referred in the anatomical literature as the retinacula of Weitbrecht [9, 27]. In 1929, Anseroff [1] published a study on the retinacula of Weitbrecht where he described in detail all the three plicae—the anterior, medial and lateral retinacula (Fig. 2). Despite profundity of the study, Anseroff attached importance mainly to the mechanical effect of the retinacula. However, the Anseroff's study fell into oblivion for many years, and was mentioned again as late as in 1971 by Wertheimer and Lopes [29]. The significance of retinacula was finally recognized in the second half of 20th by studies of blood supply to the femoral head. It has been proved that the arteries running through the retinacula are

of vital importance to vascularization of the femoral head. In 1948, Testut and Latarjet [23] published a brief description with a drawing of the medial retinaculum that they called "repli pectinéofovéal d'Amantini". Tucker [26] as one of the first authors termed them retinacular arteries. This term was subsequently used by other authors and later there appeared also the term posterosuperior and posteroinferior retinacular arteries [6, 18]. None of the studies, however, dealt in detail with the anatomy of the retinacula. Only Harty [12] mentioned them briefly in 1953 when describing blood supply to the femoral head. His article included photographs of the medial (posteroinferior) retinaculum and microscopic sections. In 1969, Bassett et al. [3] focused on the retinacula and retinacular arteries of the hip, but only in puppies. In 1990, Bartoníček [2] published a detailed anatomy of the retinacula of Weitbrecht in adults and newborns, although based only on a small number of specimens. Other studies including a larger group of specimens brought nothing new, and dealt primarily with the statistics rather than anatomy of the retinacula [10, 17]. The development of arthroscopy and magnetic resonance imaging (MRI) of the hip increased the interest in the anatomy of synovial plicae of the hip [4, 5, 15]. Therefore, we have decided to carry out a new study of the retinacula of Weitbrecht on the basis of a larger group of specimens.

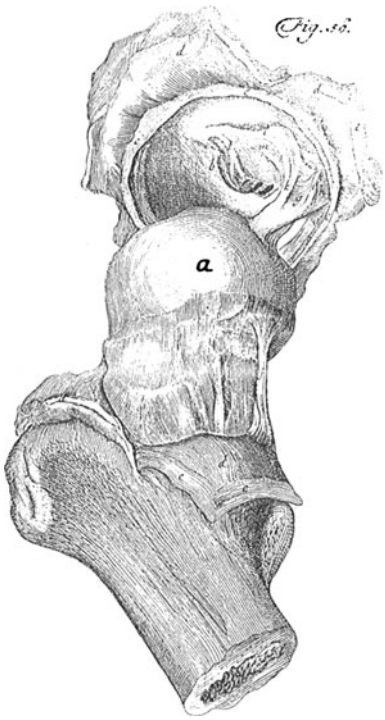

Fig. 1 Original drawing of medial retinaculum published by Weitbrecht in 1742 (right hip)

Materials and methods

Following Institutional Ethics Board approval, the anatomy of the retinacula was studied in a group of 30 adult hips (11 male, 19 female), average age of the examined specimens was 77 years (age range 43–91 years), 8 specimens were fixed by formalin solution and 22 were not fixed. The group comprised 20 right hips and 10 left hips. Excluded were all hips with progressive degenerative changes or synovitis.

The articular capsule was exposed from the anterior approach and released from its acetabular attachment by a circular cut. Subsequently, incision of anterior articular capsule was made from acetabular rim to intertrochanteric line. The articular capsule was everted towards the base of the femoral neck and the intraarticular part of the femoral neck and femoral head exposed, which allowed examination of all the three retinacula, i.e. the anterior, the medial and the lateral ones. Each plica was examined for its location, shape, width and contours and distribution as observed on an imaginary clock face. The imaginary clock system was formed by a transverse section through the neck base of the right femur when viewed from the lateral side. This section was divided into 12 sectors corresponding to the clock system used by Lavigne [16]. N. 3 was found anteriorly, N. 9 posteriorly, the greater trochanter was observed approximately between 10:30 and 1:30 o'clock, lesser trochanter between 6:30 and 7:30 o'clock (Fig. 3).

In three cases, the medial and lateral retinacula were excised and examined under microscope.

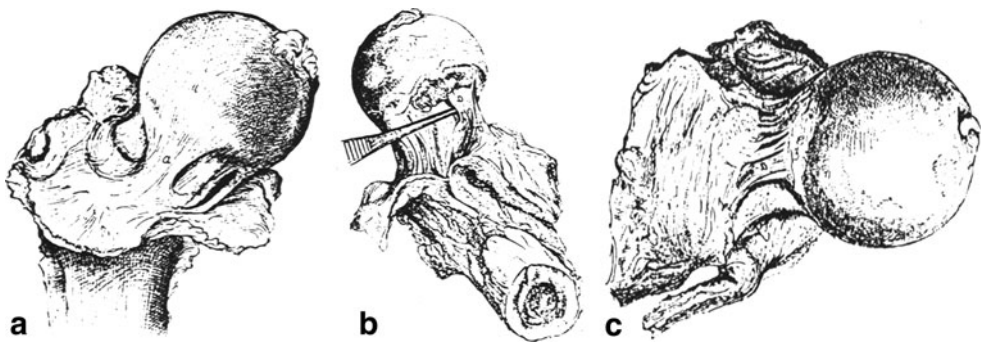

Fig. 2 Original drawings of retinacula published by Anseroff in 1929 (right hip): **a** anterior retinaculum, from anterior view, **b** medial retinaculum from inferomedial view, **c** lateral retinaculum from superior view

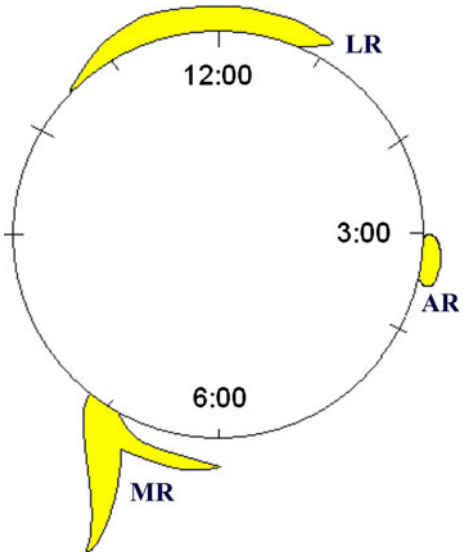

Fig. 3 Distribution of retinacula along the circumference of the femoral neck (right hip). N. 3 is anteriorly, N. 9 posteriorly: *LR* lateral retinaculum, *AR* anterior retinaculum, *ML* medial retinaculum

Results

Anterior retinaculum was the most variable of all the three synovial plicae (Fig. 4). It was absent in 60% of specimens (62.5% in males, 50% in females). Instead of the retinaculum, there were only fine plicae containing blood vessels and passing along the anterior surface of the femoral neck. In some cases, the plicae were absent and the arteries only showed through the synovial membrane. The retinaculum was found in 40% of the examined specimens (37.5% in males, 50% in females). In 83%, the retinaculum was formed by a flat plate mostly with only vague contours. Only in 17% of cases, the retinaculum was formed by two to three parallel bands.

The retinaculum always originated at the intertrochanteric line and extended proximally, in 66% of cases as far as the margin of the articular surface of the femoral head. The average width in the middle of the plica was 5.2 mm (range 1.0–20.0 mm). Using the imaginary clock system, the retinaculum was observed between 2:30 and 5:00 o'clock, most often between 3:20 and 4:10 o'clock.

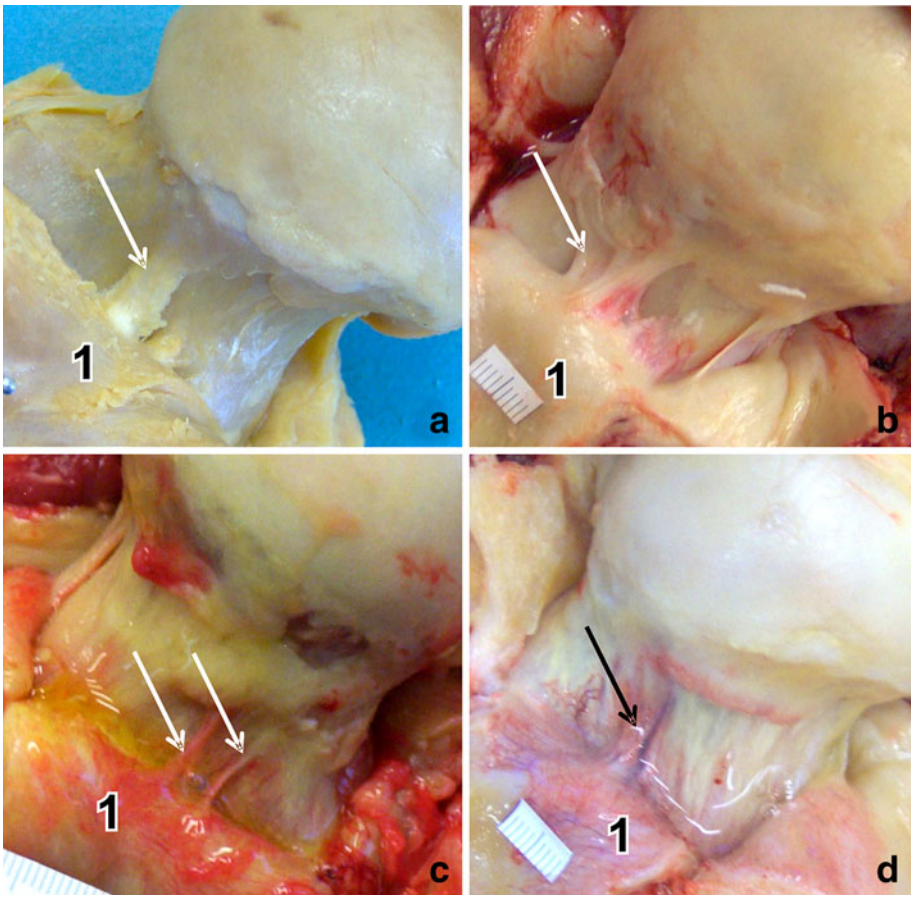

Fig. 4 Anatomy of anterior retinaculum (right hip). **a** Typical form of anterior retinaculum (plate), **b** anterior retinaculum formed by two bands, **c** anterior retinaculum is absent and replaced by prominenting subsynovial vessels, **d** anterior retinaculum is absent and replaced by subsynovial vessels showing through: *1* everted anterior articular capsule, *white* and *black arrows* indicate anterior retinaculum (**a**, **b**) or anterior subsynovial vessels (**c**, **d**)

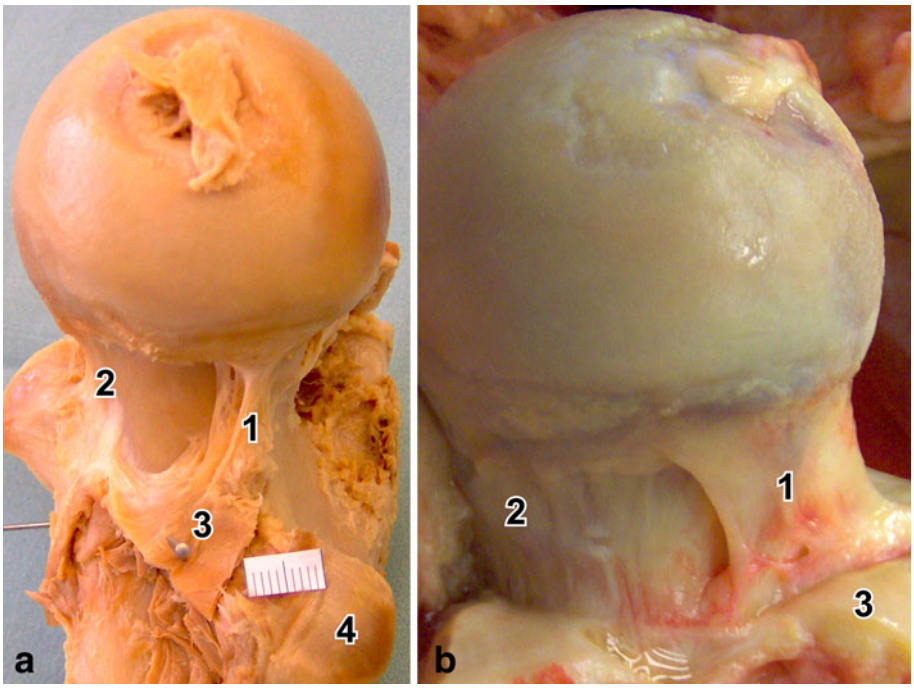

Fig. 5 Anatomy of medial retinaculum (right hip). **a** Typical form of medial retinaculum (inverted "T"), **b** medial retinaculum formed by plate: *1* medial retinaculum, *2* anterior retinaculum, *3* everted anterior articular capsule, *4* lesser trochanter

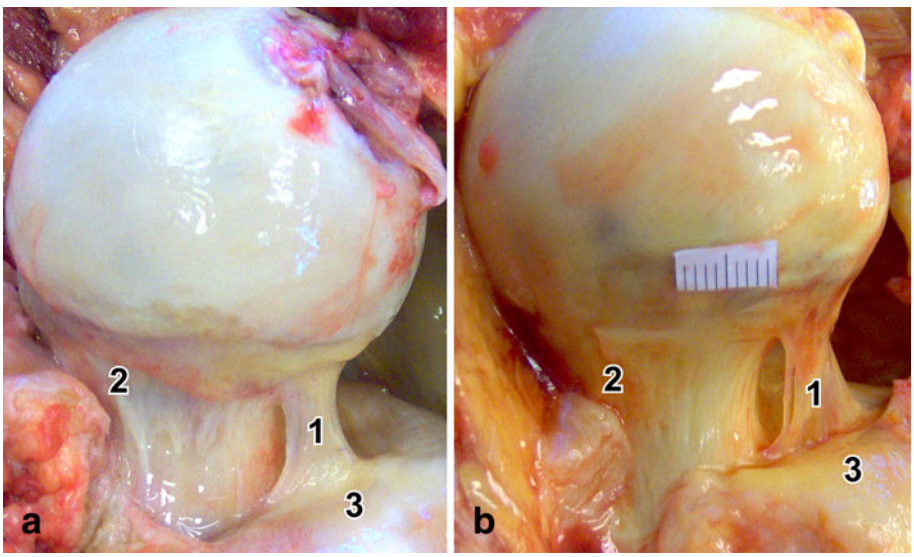

Fig. 6 Relationship between medial retinaculum and medial aspect of femoral neck (right hip). **a** A narrow opening between medial retinaculum and medial aspect of femoral neck, **b** a wider opening between medial retinaculum and medial aspect of femoral neck: *1* medial retinaculum, *2* anterior retinaculum, *3* everted anterior articular capsule

Medial retinaculum was present constantly, extending from the attachment of the articular capsule at the base of the lesser trochanter towards the fovea capitis femoris as far as the edge of the articular cartilage (Fig. 5). Typically, the retinaculum had the form of an inverted "T" or "Y". Its base was formed by a horizontal plate, narrowing proximally and transforming into a vertical plate extending towards the central fovea of the femoral head and attaching proximally at the edge of the articular surface. A deep pocket between the anterior edge of the retinaculum and the femoral neck in some cases separated the middle part of the retinaculum from the femoral neck. This arrangement could be observed in more than three quarters of the studied specimens (Fig. 6). In the remaining cases, the retinaculum was formed by two parallel vertical plicae or by one broad plate only. Of the three retinacula, the medial one was the strongest.

The average width of the retinaculum was 13 mm (range 9–25 mm) at the distal attachment and 14 mm (range 7–25 mm) at the proximal attachment. Using the imaginary clock system, the retinaculum was observed between 5:00 and 8:30 o'clock, most often between 6:00 and 6:50 o'clock.

Lateral retinaculum showed minimal shape variability. Only in 11% of cases, it was formed by several parallel bands. In 89% of cases, it had the form of a quadrilateral plate adjacent to the upper surface of the femoral neck

(Fig. 7a). This plate arises from the insertion of the articular capsule on the upper part of the femoral neck at the base of the greater trochanter close to the trochanteric fossa. The plica extended along the upper edge of the femoral neck as far as the edge of the articular cartilage. Most often the retinaculum was defined anteriorly by a synovial pocket and posteriorly by a vague contour blending with the surrounding synovialis. Less frequently was the retinaculum defined by synovial pockets both anteriorly and posteriorly, the pockets were absent or the pocket was seen only posteriorly (Fig. 7b, c). The width of the plica was constant in its whole passage and averaged 16 mm (range 7–25 mm) in the studied group. Using the imaginary clock system, the retinaculum was observed between 9:00 and 1:00 o'clock, most often between 11:20 and 12:40 o'clock.

Microscopic examination. Examination of transverse sections revealed that the retinaculum was always formed by a fatty pad containing bands of collagen fibres with elastic fibres. This stroma contained a significant number of arteries surrounded by loose fatty tissue that were more frequent in the lateral retinaculum as compared to the medial one. The surface of the retinaculum was outlined by a synovial membrane.

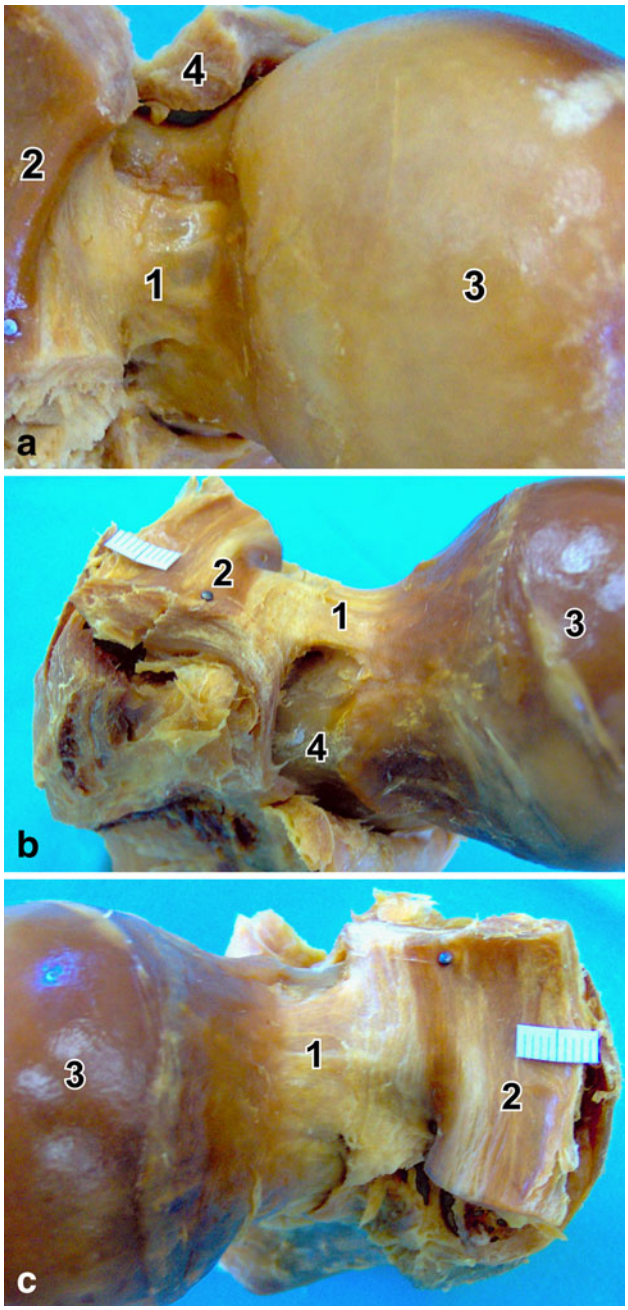

Fig. 7 Anatomy of lateral retinaculum (right hip). **a** Anterosuperior view, **b** Anterior view, **c** posterosuperior view: *1* lateral retinaculum, *2* everted lateral articular capsule, *3* femoral head, *4* posterior articular capsule (**a**) or anterior aspect of femoral neck (**b**)

Discussion

Even after 80 years of its publication, the Anseroff's study is still the most detailed source of information about the retinacula of Weitbrecht [1]. In addition to description of the retinacula, the author presented there also an interesting historical overview. In 1889, Amantini [cit. after 1] published a study on the medial retinaculum and therefore Anseroff called the medial retinaculum the Amantini's fold. Anseroff mentioned also the interesting and today hard to obtain studies of the Russian authors Sawwin, Lawroff and Tarakanoff of the beginning of 20th century.

Anseroff [1] studied the retinacula on 113 adults and 93 fully developed foetuses and newborns and in a number of mammals (baboon, macaco, lion, dog, bear, seal, sea lion, hare, horse, zebra, cow, pig, goat). The author described in detail individual retinacula in terms of their shape and variability, separately for males and females. Our findings concerning the shape of the retinacula and their variability fully correspond, but for one exception, to the Anseroff's description. The only exception is variability of the anterior retinaculum which was absent only in 7% of cases in the Anseroff's study and in 60% in our study. Such a big difference may be explained by the fact that Anseroff considered as a retinaculum also fine stripes of the synovial membrane that appeared on the anterior surface of the femoral neck after eversion of articular capsule. The anterior retinaculum showed in adults a high variability rate in terms of the existence and shape, he explained by the pressure of the iliofemoral ligament on the anterior aspects of the neck.

The only thing that can be questioned in the Anseroff's study is interpretation of the function of the retinacula. He saw their main function in mechanical reinforcement of the articular capsule and therefore called the retinacula "internal ligaments". Their significance for the course of nutritive arteries he considered as secondary. The same opinion on

mechanical significance of the retinacula was published already before Anseroff by Fawcett [9] in 1895.

The real significance of the retinacula was for the first time recognized most probably by Walmsley [27] in 1917. He described three retinacula, superior, middle and inferior, and considered them important for the course of the nutritive blood vessels of the femoral head. Highly interesting is his presentation of the retinacula in infants, which …"*are relatively larger than in the adults and we would relate the fact to the relatively larger blood-vessels which pass to the head at that period*".

Harty [12] in 1953, as the only author so far, published microscopic section of medial retinaculum that fully corresponds to our microscopic findings. Unfortunately, also his article fell into oblivion. Significance of the retinacula for the intraarticular course of the femoral neck blood vessels was again emphasized by studies related to the blood supply to the femoral head which, however, did not deal with the anatomy of retinacula [7, 8, 12, 13, 18, 20, 24–26, 29].

Significance of the retinacula of Weitbrecht can be hardly understood without knowledge of the pattern of the blood supply to the proximal femur [7, 8, 12, 13, 18, 20, 24–26, 29]. Crock [7], Ogden [18] and Chung [8] state that the deep branch of the medial circumflex femoral artery and terminal branches from the transverse branches of the lateral circumflex femoral artery created so-called basal extracapsular circle at the base of the femoral neck. This circle gives off femoral neck arteries that perforate the capsule and in their intraarticular course along the surface of the neck they are covered by the synovial membrane. Most of the femoral neck arteries run through the retinacula. Individual arteries anastomose with each other at the edge of the articular cartilage, or periphery of the capital physis where they form another, so-called Hunter's circle which gives off the terminal arteries supplying the femoral head.

Tucker [26] and Ogden [18] distinguish between three groups of retinacular arteries, namely posterosuperior, posteroinferior and anterior. The most significant are posterosuperior retinacular arteries running through the lateral retinaculum that supply two thirds to three quarters of the femoral neck. Posteroinferior retinacular arteries, also arising from the deep branch of the medial circumflex femoral artery, run through the medial retinaculum and supply the medial quarter to medial third of the femoral head [20, 24, 25, 29]. Anterior arteries are branches of the lateral circumflex femoral artery and run through the anterior retinaculum. They participate in the blood supply to the femoral head in adults only minimally, some authors [24, 25] even doubt their existence.

Correlating with significance of individual groups of retinacular arteries is also the anatomy of the retinacula of Weitbrecht. The lateral (superior) retinaculum was constantly present, with a minimal variability. The medial (inferior) retinaculum was also always present, although its shape variability was higher.

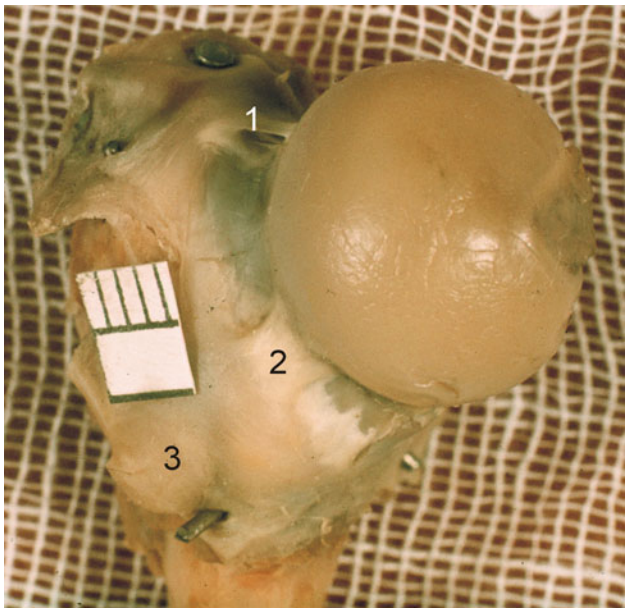

Fig. 8 Retinacula of Weitbrecht in a newborn - right hip (from Bartoníček [2] with permission): *1* lateral retinaculum, *2* broad anterior retinaculum, *3* everted anterior capsule. A clearly visible short femoral neck typical of the proximal femur in newborns

Variability of both the anterior retinaculum and anterior arteries is explained by the Ogden's study [18] and further specified by the Bartoníček's study [2]. Ogden described dependence of pattern of vessels supplying femoral head on postnatal development of proximal femur. He found out that anterior vessels constantly supplying the femoral head at birth disappear approximately in the third year of life. In Ogden's view, it was caused by pressure of the tendon of the iliopsoas and the iliofemoral ligament on the anterior aspect of the articular capsule. Bartoníček [2] found a well-developed anterior retinaculum in the joints of four newborns (Fig. 8), which supports both the Ogden's theory and the Walmsley's note.

The significance of individual groups of retinacular arteries has been proved also by the Lavigne's study [16] of distribution of vascular foramina around the femoral head and neck junction. Distribution of these apertures corresponded exactly to our finding concerning the location of retinacula. The number of nutritive foramina strictly respected significance of individual retinacular arteries.

As most nutritive arteries of the femoral head run through the retinacula, knowledge of their location is of vital importance in any operation on the hip. Arthrotomy performed on the anterior surface of the femoral neck never compromises vascularization of the femoral head. In contrast, the Hohmann elevator inserted between the capsule and the upper surface of the femoral neck may damage the

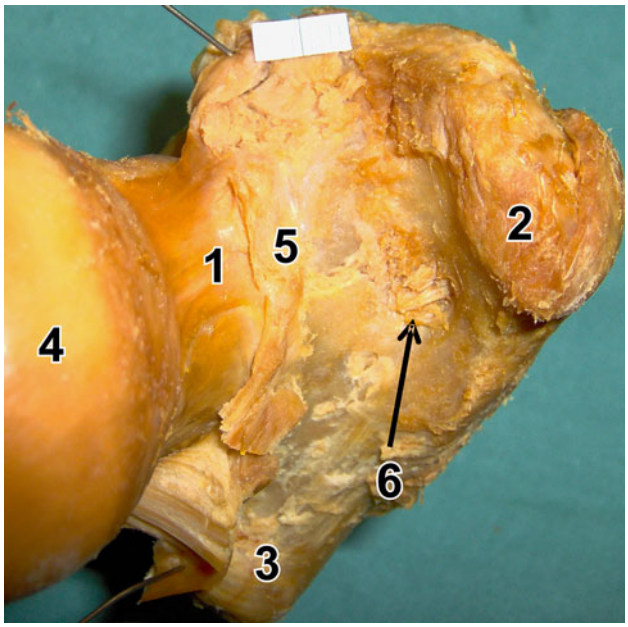

Fig. 9 Relationship between lateral retinaculum, trochanteric fossa and piriformis fossa (right hip): *1* lateral retinaculum, *2* piriformis "fossa", *3* lesser trochanter, *4* femoral head, *5* posterior articular capsule, *6* trochanteric fossa

lateral retinaculum and the arteries located there. The same applies to nailing when the entry point is located on the upper surface of the femoral neck (Fig. 9).

The medial retinaculum and the arteries located there may be damaged by the Ludloff approach during open reduction in case of development dysplasia of the hip from the medial arthrotomy. Some authors recorded ischemic complications [22].

The knowledge of anatomy of the medial retinaculum is also important for the interpretation of MRI and arthroscopic findings [4, 5, 15].

The significance of an intact medial retinaculum in displaced fractures of the femoral neck for maintenance of the contact of the medical cortex of both fragments and for blood supply to the femoral head was described by Smith [21] and later by Garden [11]. A similar detailed study was published by Papadakis et al. [19]. In a group of 112 patients, they found out that in all the 71 cases of Garden III displaced fracture of the femoral neck the medial retinaculum was intact and in 39 fractures of Garden IV type the retinaculum was torn only in 2 cases. The authors explained this fact by the strength and mobility of the medial retinaculum.

Conclusion

The medial and lateral retinacula of Weitbrecht are important constant structures of the hip. Knowledge of their anatomy is necessary for diagnostics and operations on the hip joint.

Acknowledgments This study was supported by a grant from the Ministry of Health of the Czech Republic Grant IGA MZ: NS 9980-3 Importance of intertrochanteric osteotomy and acetabular coverage procedures at adolescent and adults for preservation of long-term hip function.

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