

Clinical and Arthrographic Studies on the Valve Mechanism in Communicating Popliteal Cysts

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Summary. Forty-one knee joints presenting with significant popliteal cysts were examined clinically and arthrographically. The fluid was aspirated from the cysts and replaced by contrast medium of low viscosity. On knee flexion the contrast fluid spontaneously passed over into the joint in 16 cases (no valve mechanism), in 7 small amounts of fluid were forced into the joint when the cysts were manually compressed, and in 18 no fluid passage to the joint was observed on manipulation (valve mechanism). When a valvular action was established, effusion in the joint was rare and the fluid from the cyst was usually viscous. The cysts with a valvular connection were significantly larger than those without a valve mechanism.

Zusammenfassung. Einundvierzig Kniekehlenzysten wurden arthrographisch untersucht. Nach Abpunktieren des Zysteninhaltes und Einbringen von Röntgenkontrastmittel niedriger Viskosität wurde bei passiver Kniebeugung in 16 Fällen ein spontaner Flüssigkeitsübertritt ins Gelenk beobachtet, in sieben wurde erst nach ausgiebigem Komprimieren der Zysten geringer retrograder Gelenkübertritt erzwungen, in 18 Fällen wurde ein totaler Ventilmechanismus diagnostiziert. Beim Vorliegen eines Ventilmechanismus war der Zysteninhalt meist hochviskös, im Gelenk war kein oder nur geringer Erguß nachweisbar, und die Zysten waren signifikant größer als in Fällen, in denen kein Ventilmechanismus vorhanden war. Der prognostische und differentialdiagnostische Wert der Röntgenmethode wird erörtert.

The prevailing opinion today tends toward the view that in the great majority of cases—if not invariably—popliteal cysts arise from fluid distension of a communicating gastrocnemio-semimembranosus bursa (Gristina and Wilson, 1964; Doppman, 1965; Bryan, 1967). Recent studies have clarified the gross anatomy of this bursa and its communication with the joint (Lindgren and Willén, 1977; Rauschnig, 1979a, b). The radiographic morphology of these bursae has also been established on the basis of post-mortem radiologic investigations and studies of plaster of Paris casts (Lindgren, 1977). At scanning electron microscopy the synovial lining of the bursa displayed a similar pattern regardless of whether any communication between the joint and the bursa was present or not (Lindgren and Willén, 1977).

Simultaneous recordings of the fluid pressures occurring in the joint and the popliteal cyst during joint use have uniformly revealed the development of very high pressures in the joint and the cyst during knee flexion with weight bearing whereas on knee extension the joint pressure fell rapidly and the cyst pressure remained high (Jayson and Dixon, 1970; Lindgren, 1978a). A detailed study of the functional anatomy of the communication site by means of serial cryosectioning of undecalcified knee specimens revealed that on knee extension the aperture into the joint was completely closed, entrapping synovial fluid in the cyst, whereas the communication was actively opened during knee flexion. These observations led to the concept of a functional valve action (Rauschnig, 1979b).



Fig. 1. Selected frames from a cineradiography in a knee without a valve mechanism between the popliteal cyst and the joint cavity. The cyst has been filled with contrast medium from the joint (left), note the impressions from the gastrocnemius (g) and semimembranosus (s) tendons. Manual compression empties the contrast medium into the joint

In 1856, Foucher drew attention to the fact that on flexion of the knee the fluid contained in the cyst could be forced over into the joint, whereas this was impossible on extension. This phenomenon has since been referred to as the "sign of Foucher". Several arthrographic investigations have verified this feature in popliteal cysts (Beatty, 1959; Maudsley and Arden, 1961), as well as in all communicating gastrocnemio-semimembranosus bursae (Lindgren, 1978).

Sporadic reports have indicated that a true, unidirectional valve mechanism might be operative at the communication site, implying that the contents of the cyst cannot be manipulated into the joint even on flexion of the knee (negative "sign of Foucher"). In an arthrographic study of 20 rheumatoid knees, Hall and Scott (1966) were unable in two cases to squeeze the cyst contents into the joint although the flow in the opposite direction was unimpeded. These knees contained no effusion. Jayson and Dixon (1970) made pressure recording in 14 rheumatoid knees and on one occasion convincingly demonstrated one-way passage of fluid into the cyst. Bennett (1972) studied a synovial fistula which had developed after removal of a Baker's cyst. At arthrography it filled with contrast medium from the joint, whereas at subsequent fistulography no contrast material passed over into the knee. Recently, Lindgren (1978b) reported on arthrographic evidence of a valve mechanism in the communication of three clinically significant popliteal cysts, two of which contained highly viscous synovial fluid.

This paper reports on the arthrographic findings at the communication site in a consecutive series of 41 patients with symptoms from distended popliteal cysts. A modified arthrographic technique was developed. The radiographic findings were related to some clinical data and the diagnostic value of the methods was assessed.

Synonyms, Abbreviation and Statistical Methods

Popliteal Cysts

Baker's cysts, popliteal bursitis, (gastrocnemio-) semimembranosus bursitis, popliteal hernia.

g-s Bursa

Bursa gastrocnemio-semimembranosa (i.e., the compound bursa consisting of the bursa gastrocnemialis medialis and the bursa between the tendons of the gastrocnemius and semimembranosus muscles).

To make the information more directly available and to facilitate statistical analysis the detailed data from Table 1 were condensed to four-fold tables (Tables 2—4). The chi-square test (χ^2 -test) was then used to evaluate the relation between different clinical data and the presence or absence of a valvular connection at one degree of freedom. Statistical significance was tested at the 0.05, 0.01, and 0.001 levels.

Patients and Clinical Methods

Forty-one patients (18 women, 23 men) with a mean age of 43.5 years had been referred to the Department of Orthopaedic Surgery, University Hospital, Uppsala, most of them for pain and swelling in the popliteal space and some for articular symptoms. The duration of symptoms averaged 1.2 years. Fifteen knees had previously undergone routine arthrographic examination. The joint symptoms were assessed (Table 1) and the effusion was graded as follows: 0 = no effusion, 1 = slight effusion, positive bulge sign (Hunder and Polley, 1966), 2 = moderate effusion with cross fluctuation and patellar ballotement, 3 = considerable effusion, tense joint capsule.

With the knee flexed, the cyst was manually manipulated and squeezed. If the cyst contents could be emptied into the joint (frequently under a palpable or audible bruit), this was judged to indicate free fluid passage into the joint. If the cyst remained tense despite these manoeuvres, this was considered to indicate a total obstruction of fluid passage. Other cases were graded as indeterminate. With all detailed clinical data the patient was then referred to the Department of Diagnostic Radiology for radiographic investigation.

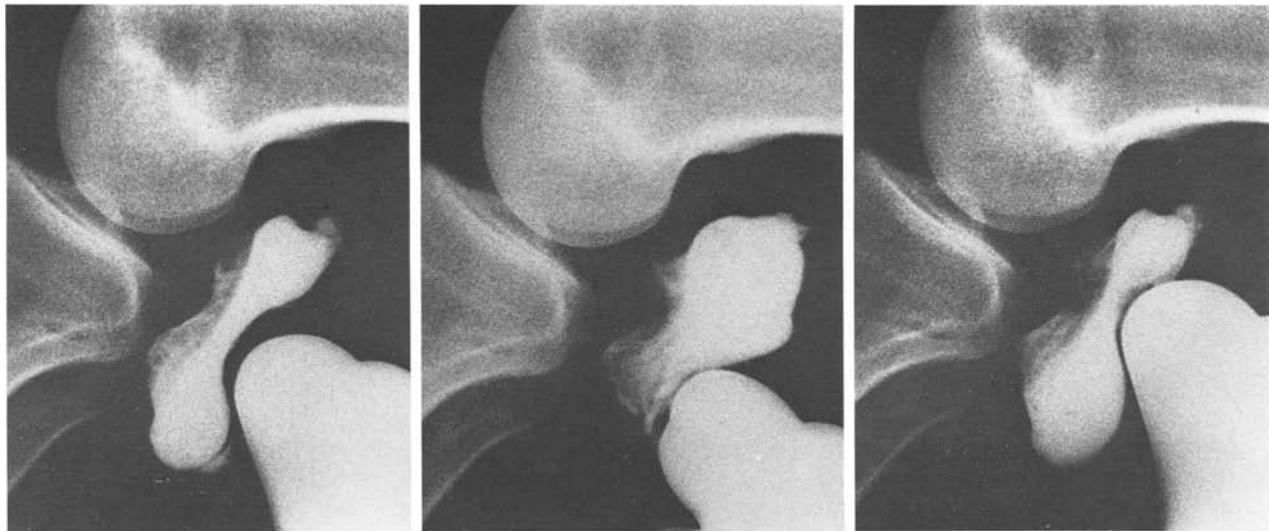


Fig. 2. Selected frames from a cineradiography in a knee with a total valve mechanism at the communication of the popliteal cyst. In spite of forceful compression no contrast medium injected into the cyst passes over into the joint cavity

Table 1. Overall clinical and radiographic data (see also Results and Tables 2—4)

Clinical data	Valve mechanism			Total	
	Total n = 18	Subtotal n = 7	None n = 16		
<i>Joint symptoms</i>					
none	7	1	—	8	} n = 41
slight	9	3	—	12	
moderate	2	3	9	14	
severe	—	—	7	7	
<i>Joint effusion</i>					
none	12	3	—	15	} n = 41
slight	6	1	5	12	
moderate	—	1	8	9	
considerable	—	2	3	5	
<i>Viscosity of cyst fluid</i>					
very high	9	2	—	11	} n = 39
high	5	1	—	6	
normal	4	4	14	22	
<i>Clinical judgement</i>					
valve mechanism	18	4	2	24	} n = 41
indeterminate	—	1	6	7	
no valve mechanism	—	2	8	10	

Radiographic Methods

With the patient lying prone and the knee extended, the cyst was punctured with a wide-bore cannula. In 16 cases, the location and extension of the cyst was determined by ultrasound B-scanning prior to puncture. All fluid was aspirated and replaced

by water-soluble contrast medium of low viscosity (Urografin 45%, Schering).

The viscosity of the fluid from the cyst was graded as *low* if it resembled normal articular synovial fluid, *viscous* if at room temperature it slowly ran along the wall of a tilted test tube, and *highly viscous* if it had a jelly-like consistency. Samples of the

Table 2. Effusion in the joint in relation to the presence or absence of a valve mechanism at the communication of the cyst*

Knee effusion	Arthrography		Total
	Valve mechanism	No valve mechanism	
None or slight	22	5	27
Moderate or considerable	3	11	14
Total	25	16	41

* $\chi^2 = 10.118$ (** = $0.001 < P < 0.01$)

Table 3. Viscosity of the synovial fluid from the popliteal cyst in relation to the presence or absence of a valve mechanism at the communication*

Viscosity	Arthrography		Total
	Valve mechanism	No valve mechanism	
High or very high	17	—	17
Normal	8	14	22
Total	25	14	39

* $\chi^2 = 22.352$ (***) = $P < 0.001$)

fluid were frozen for subsequent analysis of its physical and biochemical properties. With the knee still extended the patient was turned over to the lateral position. During cineradiography (15 frames/s, 35 mm) or fluoroscopy the knee was repeatedly flexed both actively and passively. If contrast medium then spontaneously passed over to the joint, this was considered to indicate the absence of a valve mechanism (Fig. 1). If no fluid passed over pressure was exerted on the cyst contents by squeezing and compression of its wall with the knee flexed. If under these conditions some fluid could be forced over into the joint, this was considered to imply a subtotal valve mechanism. If no fluid passed over into the joint a "total valvular mechanism" was judged to be present (Fig. 2). One or two radiographs were taken in the lateral projection, and on these the shape of the cyst, the impressions caused by the adjacent tendons and the site of the communication were studied. The product of the maximal sagittal length and width was used to express the size of the cyst (Lindgren, 1978b). In 7 patients this examination was performed after a conventional arthrography, and in 34 on a separate occasion.

Results

In Table 1 the overall findings in the 41 patients are presented. It is seen that in 18 cases a total valve mechanism was established, in 7 a subtotal valve mechanism and in 16 no valve mechanism.

Table 4. Clinical judgement on the existence of a valve mechanism in relation to the arthrographic findings*

Clinical judgement	Arthrography		Total
	Valve mechanism	No valve mechanism	
Valve mechanism ^a	23	8	31
No valve mechanism	2	8	10
Total	25	16	41

^a Indeterminate cases are included here

* $\chi^2 = 4.496$ (* = $0.01 < P < 0.05$)

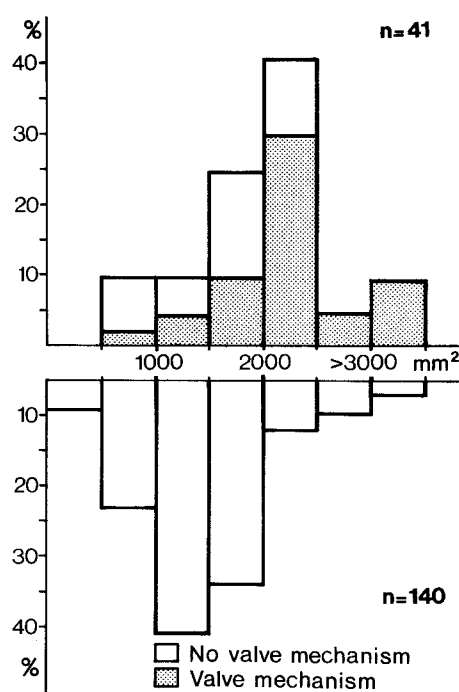


Fig. 3. Radiographic size of 41 popliteal cysts with and without a valvular communication (upper) compared to the radiographic size of 140 communicating g-s bursae seen at routine arthrography (lower), see Lindgren (1978b)

It is clear from Table 2 that effusion was rare in the knees with a valvular connection with the cyst, whereas moderate and considerable effusions were common when no valvular mechanism was present.

As shown in Table 3, the fluid in the cyst was of high or very high viscosity in 2 out of 3 cysts with a valvular connection, whereas no increase in viscosity was found in any of the cases with free communication between the joint and cyst.

Table 4 shows the correctness of the clinical judgement as to whether or not the cyst could be emptied into the joint. Arthrography revealed that 2 clinical

judgements were false positive and 8 were false negative.

Figure 3 presents graphically the percentile distribution of the cysts according to their radiographic size in relation to the presence or absence of a valvular mechanism. The mean size of the cysts was 1770 mm² (range 900—2450 mm²) when no valve mechanism was present, in cases when a valve mechanism was established, the cysts were considerably larger, on the average 2320 mm² (range 1000—5000 mm²). When viscous or highly viscous fluid was found in the cysts their mean size was 2480 mm². No positive correlation was found between the clinical data and the size of the cysts as measured at radiography.

Discussion

All popliteal cysts in this study were identified as communicating g-s bursae. Previously cases have been reported in which popliteal cysts did not fill with contrast medium from the joint and it was concluded that these cysts represented popliteal hygromas. We are convinced that a g-s bursal hygroma is an extremely rare condition. As the pressure in the popliteal cysts may be high, however, especially in the presence of a valvular mechanism and in young subjects, some provocation manoeuvre may be needed to achieve this "anterograde" filling of the cyst.

Compared with cysts examined at post-mortem radiography and with communicating, asymptomatic g-s bursae which are detected by chance at routine arthrography (Lindgren, 1978b), the cysts in the present clinical series were significantly larger. A valve mechanism was found in the majority of patients with symptomatic popliteal cysts, especially in younger ones. In consideration of the over 50% incidence of communicating g-s bursae in the normal population, however, a valve mechanism is very rare.

The specific arthrographic technique employed in this study was simple and safe and gave consistent results concerning the presence or absence of a valve mechanism, which were well correlated to the clinical findings. The results were reproducible, as demonstrated on six occasions when the examination was performed twice. We consider fluoroscopy or cine-radiography of value, as it provides information on the dynamics of the flow of the fluid and is helpful in obtaining the optimal projection for study of the orifice.

The high or very high viscosity in 18 of the cases is believed to be the result rather than the cause of the valvular mechanism, as the viscous fluid was replaced by radiopaque fluid of even lower viscosity than that

of normal synovial fluid. This fact might imply that there could have been a number of cases in which no valve mechanism was diagnosed even though synovial fluid was prevented from entering the joint. The high viscosity might be the result of water filtration through the wall of the cyst due to the high pressure gradient between the cyst fluid and the fluid in the interstitial tissue (Guyton, 1965). The question whether the high viscosity is due to merely quantitative changes of the synovial fluid or reflects qualitative differences is being investigated in an ongoing examination of the physical and biochemical properties of the fluid aspirated from these cysts (Rauschnig et al., 1979).

The *clinical conclusion* from this study is that there is little likelihood of finding associated symptoms in the joint when a valvular mechanism is operative at the site of communication with the cyst. If the fluid content of the cyst is viscous and no effusion is found in the joint, a valvular mechanism may be assumed to be present.

On the other hand, symptoms and findings indicative of an intraarticular disorder would rather preclude a valvular connection. If the popliteal cyst can be emptied by manual compression, it may be assumed that there is an underlying articular disorder and this should initiate a thorough second look for any joint focus. As shown in Table 4 a number of indeterminate cases from the clinical examination will remain as well as cases in which the articular symptoms are less pronounced and the effusion into the joint is inconstant. In such cases, the radiographic technique described in this paper is helpful in determining whether or not a valve mechanism is present at the communication site.

Although the radiographic shape of the communication of the cysts was studied with care, no morphological features were detected that explain how the valve mechanism operates. Intraoperative observations during surgery on popliteal cysts with a valvular connection have revealed that this mechanism is due to obstructing membranes. These findings will be reported in a following paper.

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