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Cyclops and cyclopoid formation after anterior cruciate ligament reconstruction: clinical and histomorphological differences

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Abstract Prospectively, 119 patients were pursued clinically and by follow-up-arthroscopy for the occurrence of a "cyclops syndrome" after ACL reconstruction with a patellar tendon autograft, augmented by LAD. Twenty-one patients showed nodular formations. Ten of these (group 1) developed early clinical evidence of a "cyclops syndrome" with a mean extension deficit of 19° before follow-up-arthroscopy, on average 5.9 months after the index operation. The nodular formations found and excised during débridement had a hard consistency. Histomorphological undecalcified microtome section evaluation of six specimens revealed fibrocartilagineous tissue with active bone formation in the center. The other 11 patients showed no clinical symptoms (group 2). A similar but soft nodulous scar formation was detected at follow-up-arthroscopy, on average 9.5 months after the index operation. Histomorphologically these so-called "cyclopoid" formations were only built-up fibrocartilagineous islands surrounded by granulation tissue. Neither remnants of tendon graft fibers nor old bone particles were found in specimens of either group. It can be concluded that both the hard cyclops and the soft "cyclopoid" are de novo scar formations.

Key words ACL reconstruction · Cyclops syndrome · Histomorphology · Tibial tunnel placement

Introduction

The "cyclops syndrome" with the clinical result of loss of motion, due to an extension deficit, was first described by Jackson et al. in 1990 [5]. They postulated that the postarthroscopic ACL reconstruction development of an intra-articular nodule (= cyclops), leads to impingement of the patellar tendon graft in the intercondylar notch. The major hypotheses on the origin involve granulation tissue arising from collagen fibers of the patellar tendon graft, or a prolonged deficit of motion [5, 8].

This prospective study recorded the incidence of the "cyclops syndrome" in our patients after ACL reconstruction to evaluate histologically the type and origin of tissues constituting the cyclops, to determine the correlation between cyclops formation and tibial tunnel placement, and to assess the improvement associated with excision of the nodule after arthroscopic débridement.

Materials and methods

Between January 1992 and December 1993, 120 patients (66 men, 54 women; average age 26 years) underwent an acute or delayed arthroscopic reconstruction of a torn ACL with an ipsilateral bone-, patellar tendon-, bone graft and augmented by a synthetic implant (LAD; 3M, St. Paul, Minn., USA) in a divergent route and rigid double-end fixation technique [6]. Acute reconstruction was defined as that performed within 6 weeks after ACL injury (n = 28). In 27 patients a tear of the medial meniscus was found, while 11 patients showed a tear of the lateral meniscus. The medial collateral ligament was ruptured in 2 patients, the lateral collateral ligament in 3, and the posterior cruciate ligament in 2. In 21 patients chondral lesions were found arthroscopically, and in 48 a notchplasty was performed. Postoperatively the knee was fixed in a

brace, and after 10 days S 0°–90° by full weight bearing was allowed. All patients underwent the same physiotherapeutic program, including postoperative continuous passive motion, isometric exercises, and a proprioceptive rehabilitation program. Competitive sports were allowed after 3–6 months if the obtained thigh circumference had reached that of the contralateral level.

Patients were prospectively followed for the occurrence of a "cyclops syndrome" (i.e., limited extension, crepitus at terminal extension). One patient was excluded after moving abroad. Follow-up arthroscopy was performed when either an early deficit in range of motion demanded arthrolysis by débridement (group 1), or approximately 6 months later while removing the LAD fixation device (group 2). After detection of intra-articular nodulous scar formation and measurement with a scaled probe, this was totally excised during débridement. Intensive physiotherapy was prolonged to treat persistent range of motion deficit.

The retrieved specimens were fixed in 2.5% buffered glutaraldehyde for histological evaluation. After rinsing in the buffer and dehydration in graded ethanol they were embedded in methylmethacrylate, and 5-mm thick undecalcified microtome sections were prepared ("K-microtome," Reichert-Jung, Vienna, Austria). After appropriate staining [15] the sections were examined under transmitted and polarized light microscopes.

Placement of the tibial tunnel was examined on lateral radiographs. The index between the distance between the ventral edge of the tibia and the tunnel on joint line level (A) and the diameter of the proximal tibia (A+B) was calculated (Fig. 1) and compared between the groups. For the statistical comparison of the results Student's *t* test was used, with a *P* value of less than 0.05 being taken as statistically significant.

After a follow-up period of at least 18 months patients were called for a check-up. The investigation included clinical examination, subjective symptom and activity level analysis, functional testing, and radiography. Range of motion was measured goniometrically with the patient supine. The clinical outcome of all patients was assessed with the evaluation sheet of the Orthopaedische Arbeitsgemeinschaft Knie (OAK) [11].

Results

A nodulous scar formation was detected in 21 of the 119 patients at follow-up arthroscopy (Table 1). However, the clinical symptoms of a "cyclops syndrome" had been observed in only ten of these patients (group 1; seven men, three women; mean age 30 years, range 24–50). Follow-up arthroscopy was performed an average of 5.9 months (range 4 to 14 months) after ACL reconstruction. Five patients underwent acute ACL reconstruction. One patient underwent repair of a grade III medial collateral ligament tear during ACL reconstruction. Meniscal lesions were present in six patients. One medial meniscus tear was repaired, three lateral and one medial meniscus tear required partial menisectomy, and one medial and one lateral meniscus tear were judged as stable. In these ten patients the hard nodulous formation found in front of the intercondylar notch, had a mean size of 14 ± 4 mm by 8 ± 2 mm). Removal of the nodule resulted in extensional improvement from a preoperative loss of 19°, to 7° after surgery (Table 2).

Eleven patients (group 2; six men, five women; mean age 27 years, range 15.5–48) showed no clinical symptoms (i.e., free range of motion) prior to follow-up arthroscopy and yet scar formation with similar macroscopic appearance to the cyclops, but softer and smaller (mean size: 8 ± 3 mm by 6 ± 2 mm) was detected in front of the intercondylar notch. We termed this arthroscopic finding "cyclopoid." Four patients were operated on in the acute phase. Five patients had meniscal lesions at the time of ACL reconstruction. Two lateral and three medial meniscus tears required partial menisectomy, and one medial meniscus was totally resected. Follow-up arthroscopy was

Table 1 Patient data

Group	Males, females	Mean age (years), range	Acute ACL	Chronic ACL	Notchplasty
1	7, 3	30, 24–50	5	5	10
2	6, 5	27, 15–48	4	7	4

Table 2 Limitations in range of knee motion present before and after arthroscopic débridement (*AS*) and at follow-up (group 1)

	Extension	Flexion
Before follow-up AS	19 ± 10°	30 ± 16°
After follow-up AS	7 ± 4°	16 ± 9°
Follow-up	4 ± 4°	13 ± 9°

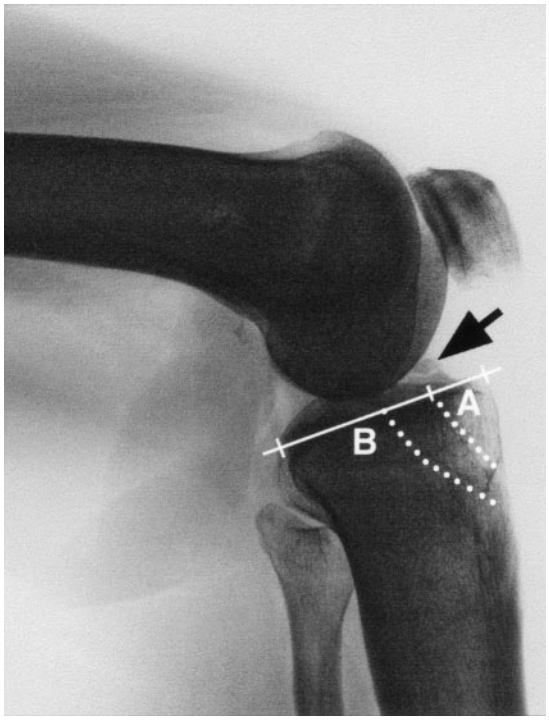

Fig. 1 Calcification in front of the ACL graft before arthroscopic débridement in a 30-year-old tennis player who underwent ACL reconstruction 10 days after injury. Measurement of the tibial tunnel index: A/(A+B)

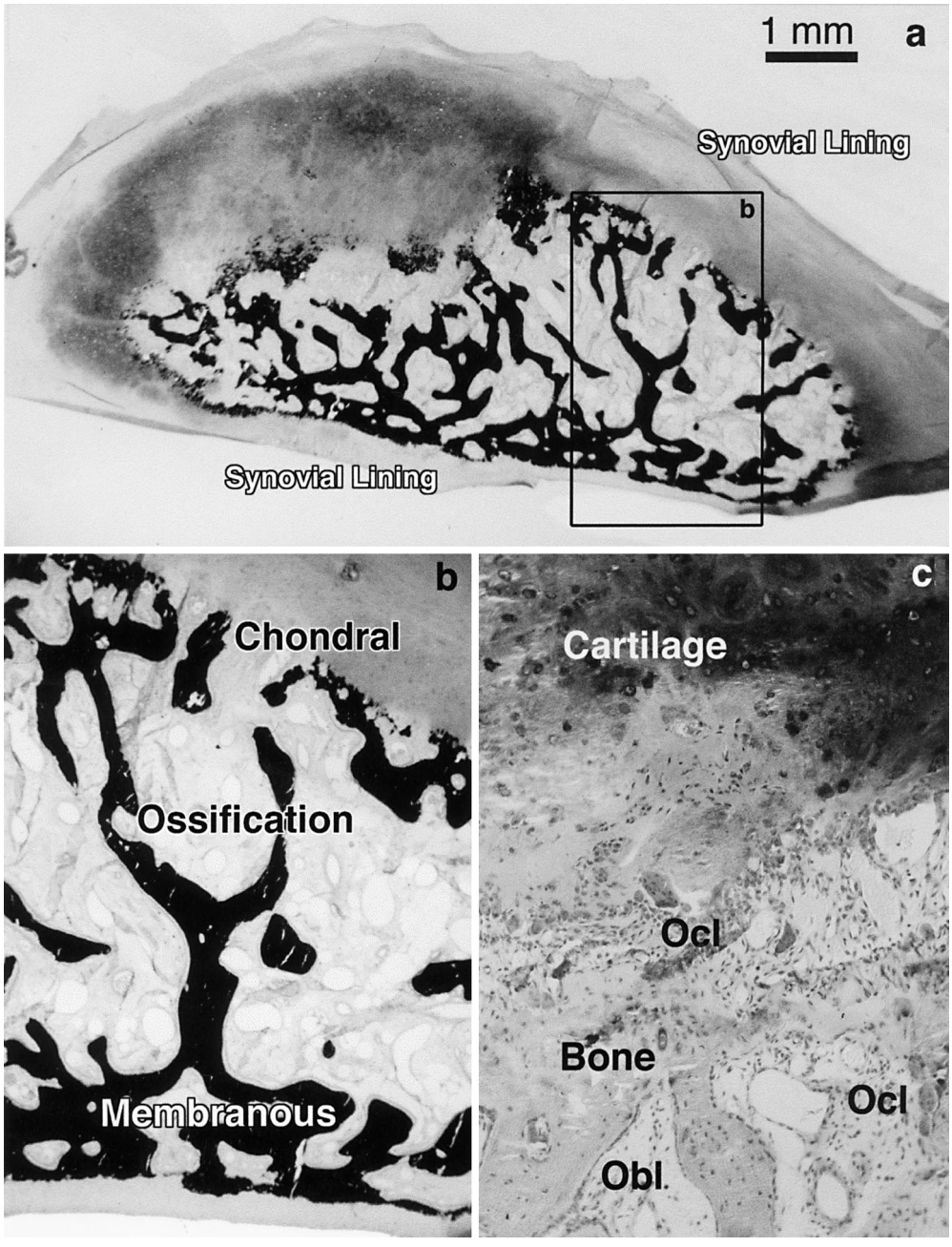

Fig. 2 **a** The mineralized matrix is stained black, and the cyclops is covered by a synovial membrane. Methylgreen-pyronin staining (Krutsay), × 3.5. **b** The detailed picture shows both the chondral and the membranous ossification process in the cyclops. Methylgreen-pyronin staining (Krutsay), × 8. **c** In a different staining technique (Giemsa) and at a greater magnification (20 ×) both osteoclasts (*Ocl*) and osteoblasts (*Obl*) can be seen

performed on average of 9.5 months (range 5–25) after the index operation.

Histomorphological examination was possible in 10 patients (six from group 1, four from group 2). In the other 11 patients only small fragments of the nodules were retrieved, and these did not allow identification or orientation in the biopsies. In five patients from group 1 the calcified core of the cyclops were seen even on the lateral radiographs (Fig. 1).

Histomorphologically the specimens of group 1 showed chondral and membranous ossification. There were signs of new bone formation with activity of osteoblasts and osteoclasts. Tissues showed evidence of good vascular ingrowth. There was no inflammatory cell infiltration or granulation tissue (Fig. 2). In the cyclopoid formation excised from group 2 no bony formation was seen in any of the specimens. The cyclopoid scar formations were built up of fibrous tissue showing elements of granulation tissue and in two specimens areas of cartilaginous tissue. A hypervascular granulation tissue was surrounded by a mature, well organized fibrous capsule. None of the specimens contained elements of the tendinous graft (Fig. 3).

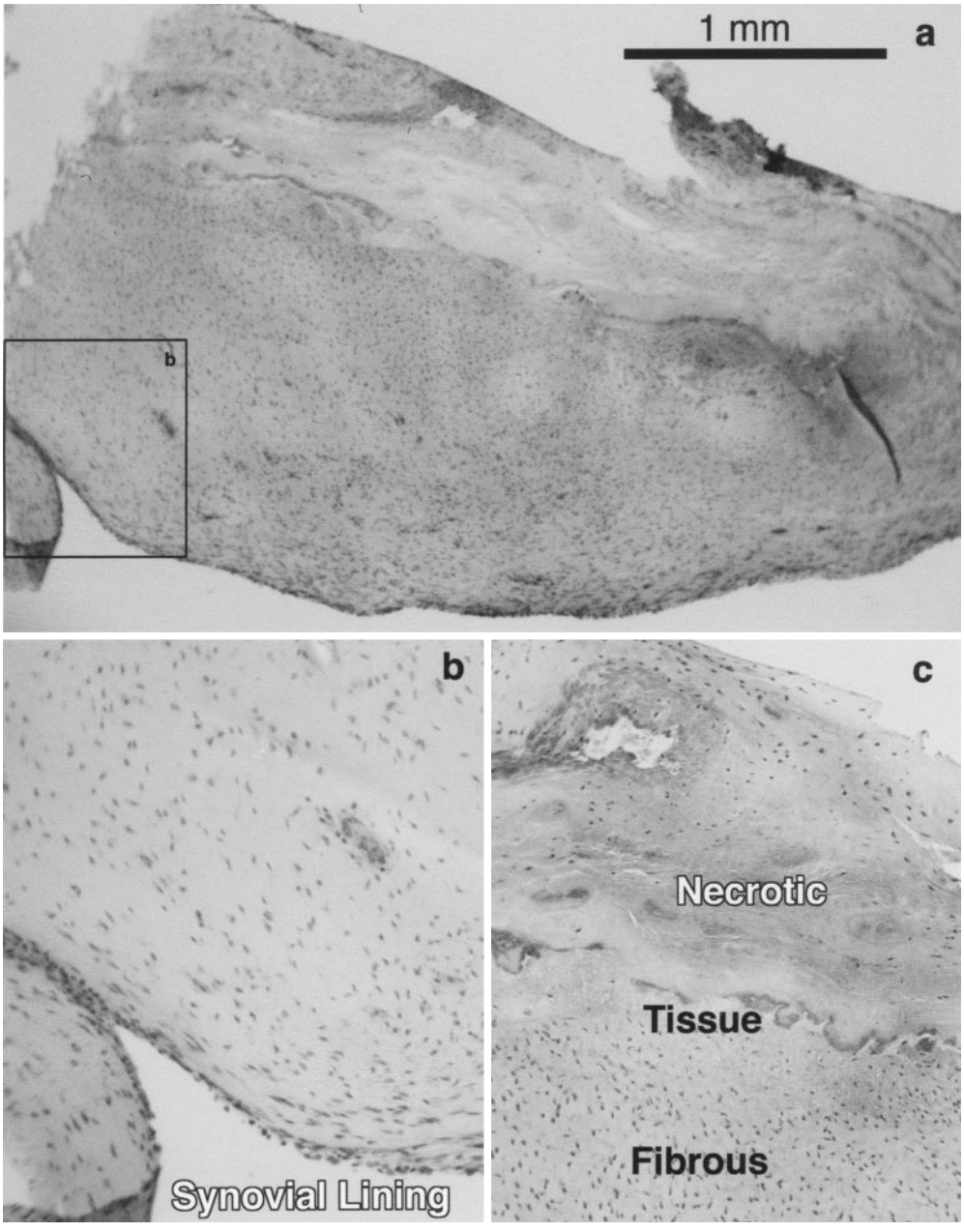

Fig. 3 **a** The cyclopoid scar formation appears as fibrous tissue with a synovial lining. Giemsa, × 8. **b** The synovial lining is shown in this cell rich, but poorly vascularized tissue. Giemsa, × 20. **c** In a different staining technique (toloidin blue, × 8) both necrotic and fibrous tissue can be seen more clearly, and the absence of metachromasia indicates that no cartilaginous matrix is present

The radiological investigation measurements of the tibial tunnel placement revealed no statistically significant differences between groups 1 and 2. The ratio of A/(A + B) was on average 0.33 ± 0.06 in group 1 and 0.36 ± 0.08 in group 2.

The follow-up period was similar: 22 months (18–29 months) in group 1 and 21 months (18–29 months) in group 2. In group 1 two patients achieved excellent results, three good, three fair, and two poor. In group 2 eight patients were graded as excellent, 2 as good, and 1 as fair.

Discussion

Arthrofibrosis is defined as a continuous loss of knee extension of more than 10° and as a loss of flexion of 15° or more [9, 14, 16]. Primary arthrofibrosis with generalized adhesions still remains an unpredictable phenomenon [14]. The cyclops syndrome, a rare cause of secondary arthrofibrosis, is due to an impingement of scar formation anterior to the tibial tunnel in the intercondylar notch. The two development theories for this lesion are: (a) ventral impingement of the graft and ventral fiber breakage which

forms the fibrous nodule, as described by Marzo et al. [8] and Fullerton et al. [3]; (b) cartilaginous or bony fragments which were left around the tibial tunnel, as described by Jackson et al. [5].

In the present study only specimens of adequate size allowing definition of orientation and depth of biopsies were interpreted in the histomorphological examination. Delcogliano et al. [2] observed no newly formed bone or necrotic lamellae and no cartilaginous or fibrocartilaginous tissue in cyclops formations investigated under light and scanning electron microscopes. Marzo et al. [8] state that disorganized fibrous connective tissue, which undergoes fibrocartilaginous metaplasia with time, is the most common finding in the cyclops formations examined microscopically. In the present study the cyclopoid scar formations excised in patients from group 2 consisted of connective tissue containing intermittent small areas of cartilaginous tissue. The smaller average size of the excised nodule than that in the study of Marzo et al. [8] could explain the lack of knee motion limitations in the 11 patients. However, their average time interval between ACL reconstruction and arthroscopic débridement was longer (11 as opposed to 9.5 months). In the present study symptomatic patients with an extension loss underwent arthroscopic débridement after an average of 5.9 months postoperatively. All these patients revealed larger nodules consisting of bony cores with areas of cartilaginous tissue.

To exclude an overly anterior tibial tunnel placement its position was measured on lateral radiographs. This was not performed in the two studies cited above. However, the radiological investigation showed no evidence of incorrect tunnel placement (i.e., ideal tunnel placement in almost all patients) or any differences between the cyclops (group 1) and the cyclopoid scar formation (group 2) groups. These results can be interpreted as exact tunnel placement and are comparable to those of other investigators [4, 7].

The occurrence rate reported in the literature of a cyclops syndrome varies from 2.2% [2] to 21% [1]. In this study a rate of 8.4% was found. Due to the small number of patients developing a cyclops formation after ACL reconstruction only trends regarding predictive factors can be observed. A primary notchplasty was carried out in group 1 twice as often as in group 2. A predisposition for arthrofibrotic changes may be the stimulation of connective tissue proliferation. However, it is evident that the graft needs enough space. It is also possible that some of these problems are due to augmentation with a synthetic device. Since recent studies have shown that the LAD augmentation of a patellar tendon graft has no benefit [12, 13], the treatment protocol of our clinic was changed, and only multiple suture repair is augmented with the LAD to achieve good results, as reported previously [6, 17]. With the improvement in surgical techniques for ACL reconstruction and an aggressive rehabilitation concept [10], fewer problems have been observed in the postoperative course than previously.

As our study reveals, there are two histomorphologically different forms of nodulous scar formations. We believe that these lesions are stimulated by the debris raised from the drilling and preparation of the tibial tunnel. Neither remnants of tendon graft fibers nor old bone particles were found in the specimens of either group, and it can therefore be concluded that both the hard cyclops and the soft "cyclopoid" are de novo scar formations, seemingly subjected to different biomechanical stresses. As not only the extension was limited in the cyclops group but also flexion, we further believe that the development of this nodulous scar formation is the expression of merely a generalized inclination to fibrotic healing. It is still unknown whether a cyclopoid scar formation can develop into a cyclops by itself or perhaps by cellular modulation due to compressive forces.

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