

## RECENT INJURIES OF THE LIGAMENTS OF THE KNEE JOINT IN CHILDREN<sup>1</sup>

By

HANS EMNEUS

Injuries of the ligaments of the knee joint present many problems: they are not readily recognised in the acute stage, it has not yet been altogether determined which therapeutic measures promise the best results, and if the condition remains undiagnosed, or if treatment is delayed or inadequate, sequelae may prove troublesome and obstinate.

In 1952 and 1953 the number of children seen at the Department because of injuries of the ligaments of the knee joint was higher than usual. This prompted the writer to start the present investigation, the purpose of which was to determine whether there was reason to make any distinction between such injuries in children and in adults.

*Palmer, Brantigan & Voshel* and *Janik* carried out detailed investigations of the anatomic and pathophysiologic mechanism of injuries of the ligaments. The problems stressed by these investigators are too extensive to be discussed in detail here. They all stressed that the knee joint should be considered as a whole, i.e., the individual ligament should be considered against the background of the interplay between the bones, musculature and ligaments.

Various factors are believed to favour rupture of a ligament such as weakness of the ligament, earlier partial rupture with cicatrisation, over-training and insufficient exercise.

Of the various classifications of different types of violence capable of rupturing the ligaments, that presented by *Palmer* is probably the most perspicuous. He describes four typical movements liable to lead

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<sup>1</sup> Not including injuries to, or changes in, the meniscus.

to subluxation of the knee joint. These four types embrace the most common sequence of events causing severe distortion of the knee.

1. *Hyperextension subluxation*.—This is caused by direct violence to the anterior part of the extremity near the knee joint or by indirect violence, e.g. if the leg is stretched, violence in the longitudinal direction of the femur will cause hyperextension-subluxation. A fall from a cycle or stumbling is liable to cause this type of injury.

2. *Combined abduction-subluxation*.—Violence to the lateral aspect of the knee joint or indirect violence during a fall obliquely forwards when walking or running. Such indirect violence produces a typical abduction-luxation, composed of abduction, flexion and supination. Injuries of this type often occur when ski-ing or playing football.

3. *Combined adduction-subluxation*.—This type is the result of direct violence against the inner aspect of the joint or indirectly by combined adduction, flexion, pronation during forward movement. This type is rare.

4. Subluxation of “drawer backwards” type is caused by direct violence to the anterior aspect of the lower leg when the knee is flexed at 90°. This type of injury is seen in ski and motorcycle accidents.

*Palmer* found type 2 to be most common in his material and to include isolated injury to the medial collateral ligament and the many combined injuries, where combined injury to the anterior cruciate ligament and the medial collateral ligament was predominant.

Type 1 includes the fairly common isolated ruptures of the anterior cruciate ligament; and type 3, the rare injuries of the lateral collateral ligament.

Isolated ruptures of the posterior cruciate ligament are found in group 4.

In children type 1 is most common (hyperextension-subluxation). Children are often awkward in their movements and readily hyperextend their joints.

Closure of the epiphyseal line is an acceptable criterion for distinguishing adults from children. This occurs at the age of 16–17 in males and 15–16 years in females.

In the large monographs on ligament injuries the materials include a few cases in children, but they were not distinguished in any respect from those in adults.

*Palmer's* series included 3 children, all boys, aged 11, 13 and 15 years. All of them had isolated rupture of the medial collateral ligament, anterior cruciate ligament and posterior cruciate ligament,

respectively, the last 2 with bone fragments from the attachment on the tibia. *O'Donoghue's* series also included 3 children: 1 girl aged 6, and 2 boys, both aged 16. One of the boys had a rupture of the medial collateral ligament, the other of the lateral collateral ligament. Nothing is said about the site or nature of the injury in the girl.

*Janik* described a case of injury to the anterior cruciate ligament in a girl, aged 11.

*O'Donoghue* found a high frequency in the 18–20 year age classes and pointed out that only one of the patients was below 15 years of age.

Some authors have described small series of fractures of the tibial spine and of the eminentia inter-condyloidea tibiae in children. There is reason to believe that these cases might just as well have been classed under the heading of rupture of the anterior or posterior cruciate ligament. However, *Palmer* pointed out that he had once performed arthrotomy of the knee joint in the belief that the cruciate ligament had been avulsed, but that the operation revealed a patellar fragment, which, owing to its position just above the eminence, had led to a false pre-operative diagnosis. It should also be borne in mind that no ligament is attached to the lateral tubercle of the intercondyloid eminence.

*Palmer* described a fracture of the lateral tubercle together with an injured ligament, but stressed that it was not an avulsion fracture, with which it should not be confused. The appearance and site of the stump of a ruptured cruciate fragment are typical. This also applies to the stump of a ruptured posterior ligament. *Palmer* and later *Olof Johansson* considered it more correct to classify these cases as rupture of the ligament with bone fragment.

It appears that both *Smillie* and *Watson-Jones* are of the opinion that fracture of the tibial spine is identical with rupture of the anterior cruciate ligament, at least in children.

#### AUTHOR'S MATERIAL

The material consisted of all recent injuries seen during the years 1934–1954 at the Department of Orthopaedic Surgery, University Hospital, Lund, in boys and girls in whom the epiphyseal lines had not yet closed.

*Collection.*—Analysis of the records included examination of cases in which rupture of the ligaments might have been concealed under

the diagnosis of e.g. distortion and hemarthrosis. However, no definite cases of rupture of the ligament were found under these headings. In addition, the records of all cases of laesio or rupt. menisci and all operation reports of arthrotomies were examined to find out whether operation had not revealed rupture of the ligaments that had not been noted in the diagnosis. One case of partial rupture of the medial collateral ligament was discovered in this way. Only patients below 20 years of age were accepted.

All records of patients who had been admitted because of sequelae from injury to the ligaments were analysed in order to determine whether the accident had occurred during childhood or adolescence. Among these were a few who appeared to have dated the injury to the time they were 18-19 years of age and were therefore excluded, and one case in which the injury had occurred at the age of 10 and was not treated until 3 years later when the patient was admitted to the department. This case will be discussed later separately.

In this way 26 cases of well defined recent ligament ruptures were traced, of which 17 still had epiphyseal cartilage at the time of the injury.

Rupture of the medial collateral ligament .....	4
Rupture of the anterior cruciate ligament .....	11
Rupture of the posterior cruciate ligament .....	1
Rupture of the lateral collateral ligament .....	1
	17
Total .....	17

In the 4 cases of rupture of the medial collateral ligament rupture was only partial with avulsion of the ligament from its attachment on the femur. This also applies to the case of injury to the lateral collateral ligament.

In the 11 cases of rupture of the anterior cruciate ligament the rupture was located at the attachment on the tibia and varying-sized bone fragments were seen. The rupture of the posterior cruciate ligament was located in the posterior tibial intercondyloid fossa and roentgenology revealed the avulsion of a thin fragment of bone.

The material included no combined injuries but in 2 of the ruptures of the anterior cruciate ligament small pieces of the lateral tibial condyle had been avulsed. The typical combination of rupture of the medial collateral ligament and the anterior cruciate ligament was not seen. In some of the cases the records contained notes of tenderness

over the joint or femoral condyle as well as the usual symptoms. This might suggest partial weakness of the medial collateral ligament, although no mention of this had been made in the records. At any rate the material did not contain any case with combined total rupture of the medial collateral ligament and of the anterior cruciate ligament.

It might also be mentioned that the material did not contain any case of complete rupture of the medial collateral ligament. The findings made in these cases differed from what might be expected in the representative adult material. The differences are:

1. Lack of typical combined injuries.
2. All of the injuries of the cruciate ligaments were located at the attachment of the tibia and with avulsion of its attachment.
3. The material included no case of complete rupture of the medial collateral ligament.

Several explanations can be offered for these differences. The material may have been selective in various respects and therefore not representative. The cases referred to us might have been selected, *i.e.*, included only roentgenographically verified cases. If the children seen by us had been selected, the remainder should have been seen at the Children's Section of the Surgical Department. But this was not so, at least during the years 1945-54. The latter explanation is also less likely, because the diagnostic possibilities have hardly changed during the 20-year period.

The material is not large, but it is based on the records from a large central hospital. Nevertheless, conclusions should be drawn only with caution.

An observation arguing for the material being representative is that, as mentioned earlier, the few cases in *Palmer's*, *O'Donoghue's* and *Janik's* material were of the same character as in our series, namely fracture of the tibial spine and isolated rupture of the collateral ligament. In addition, the small series of fracture of the tibial spine such as those presented by *Roth*, *Lee* and *Bradford* contained several cases of infants and they were of the same nature.

Reports of ruptures of the medial collateral ligament in children are rare. This can surely be explained by the fact that in children the ruptures are only partial and then they are diagnosed as *distorsio gen.* In our 4 cases of rupture of the medial collateral ligament the symptoms were considerable. As mentioned, the material contained no recent complete rupture of the medial collateral ligament, but one

13 year old patient with sequelae from such an injury has been treated here. Three years after the accident that patient was admitted to the Department, where it was found out that medical advice was not sought in the acute stage and that the joint had been treated with poultices. On admission the patient had considerable symptoms and a lateral instability of  $10^{\circ}$ . He was not operated upon. Quadriceps gymnastic drill gave relief. When questioned by letter 15 years after the admittance the patient stated that he still had occasional moderate trouble on more than usual exertion of the knee.

It appears that, as might be gathered from *Watson-Jones*, rupture of the cruciate ligament in children very often assumes the form of fracture of the tibial spine and that complete rupture of the medial collateral ligament is rare in children as compared with adults. It also appears that combined injuries, which are the rule in adults, are exceptional in children, i.e. partial rupture of the medial collateral ligament can very well be concealed in cases with fracture of the tibial spine, but then it is, as a rule, of no practical therapeutic importance.

Any explanation why injury to the cruciate ligament in children assumes the character of fracture of the tibial spine cannot be more than tentative. *Smillie* suggested that the ligaments in children are stronger than in adults, where degenerative processes might occur. Therefore, ruptures occur in the osteochondral attachments. This explanation is plausible but is difficult to bring into line with *O'Donoghue's* series, where the very large number of young persons about 20 years of age and in whom degenerative changes of the ligaments can hardly be expected, nevertheless found many with ruptures of the ligament substance. On the other hand, *O'Donoghue's* material is composed of American sportsmen (Rugby and baseball players) and their joints are exposed to much greater stress than the population in general. As mentioned, children are awkward and prone to hyperextend the joints while playing and therefore a higher frequency of subluxation because of hyperextension must be expected and this might be one explanation.

#### TREATMENT

*Palmer* (1938) recommends surgical treatment in all cases of complete rupture, and if the rupture is only partial immobilisation in plaster for 3-6 weeks.

On the whole *Smillie* shares *Palmer's* views, although he recommends conservative treatment of isolated ruptures of the anterior cruciate ligament but surgical treatment if the injury is combined. As to fracture of the tibial spine, *Smillie* suggests that exact reduction should be aimed at, and if this is not possible by the close method, open reduction and fixation should be done.

*O'Donoghue* on the basis of an analysis of 80 personal cases recommends early surgical intervention.

No special type of therapy is recommended for these injuries in children. Since the injuries in children are of the special nature described above, we have followed the recommendations of *Smillie* for treatment of fracture of the tibial spine. As far as partial rupture of the medial collateral ligaments are concerned, *Smillie* advises elastic bandage only. Like *Palmer* we have preferred immobilisation for a short time of, say, 2-3 weeks.

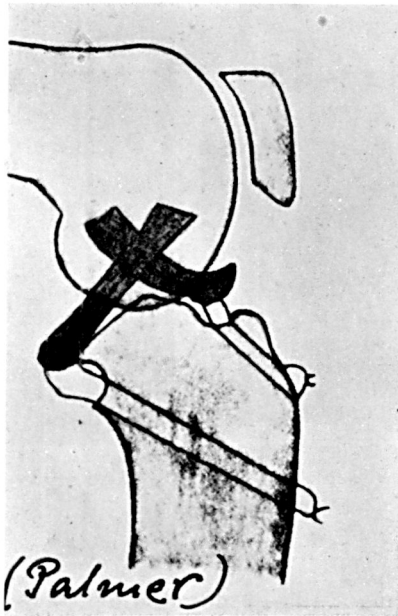
Four cases of rupture of the anterior cruciate ligament were treated surgically. The 4 cases of rupture of the medial collateral ligament, the one with rupture of the lateral collateral ligament, 7 cases of rupture of the anterior cruciate ligament and 1 case of rupture of the posterior cruciate ligament were treated conservatively.

In one of the cases with rupture of the medial collateral ligament arthrotomy was done because of assumed injury to the meniscus, but no such injury was found at operation. The partial rupture of the collateral ligament was situated at the femoral epicondyle and was verified at arthrotomy, but no suture was done. The knee was immobilised for 2 weeks after operation (Case 1).

In 3 of the 4 cases operated upon because of rupture of the cruciate ligament we applied the same technique as *Palmer* and *Smillie* (see Fig. 1). In one of the cases reduction was possible in connection with arthrotomy and the surgeon in charge did not consider osteosynthesis necessary.

As far as ruptures of the cruciate ligament are concerned conservative treatment consisted of evacuation of hemarthrosis, reduction and immobilisation of the knee in plaster for 6 to 7 weeks. Intense quadriceps drill was started the first day after immobilisation of the knee. After removal of the plaster quadriceps drill was the main therapy.

In cases of rupture of the medial collateral ligament hemarthrosis was not large and therefore the knee was not punctured. The knee was immobilised on the average for 3 weeks with subsequent quadriceps drill. The case of rupture of the lateral collateral ligament had hemar-



*Fig. 1.*

Sketch of operation illustrating the procedure for suturing ruptures in the tibial insertions of both the crucial bands. From Palmer: *Acta chir. scand.* 81, suppl. 53, 1938.

throsis, which was evacuated, after which the knee was immobilised for 3 weeks.

Of these 17 patients, 16 were reviewed. The one not reviewed was the patient in case 6, which could not be traced. Thirteen had made a complete recovery, *i.e.*, they had no symptoms, no quadriceps atrophy, gross functional strength of the muscles of the knee joint was normal as compared with the other side, there was normal mobility and stability. Three cases (3, 7 and 9) showed slight deviations from the healthy side, thus:

In case 3 with rupture of the medial collateral ligament, examined 4 years after the injury, the 16-year old patient stated that he occasionally had tenderness over the med. femoral condyle after football. Clinically and roentgenologically the knee was normal.

In case 7 (anterior cruciate rupture examined 13 years after injury) the patient had no symptoms, but there was a quadriceps atrophy of about 2 cm and when getting up onto a chair 50 cm high with the injured leg first, a distinct reduction in the functional strength of the



*Fig. 2 A.*

Case 8. Rupt. of the ant. cruciat. lig. in a ten year old boy. Before closed reduction.



*Fig. 2 B.*

The same as 2 A, after closed reduction.

quadriceps on that side was observed. But 1 year before the injury (1940) both legs had been operated upon because of congenital luxatio habitualis patellae and there was a persistent tendency to lateral subluxation of the patella on flexion of the knee over  $90^\circ$ . The patient stated that he had never noticed that the quadriceps on that side was weaker. It appears probable that the atrophy and relative insufficiency was ascribable to the persistent tendency to subluxation despite Krogius plasty.

Case 9.—The anterior cruciate rupture was examined 2 years and 9 months after the injury. The patient had made a complete recovery. There was 1 cm quadriceps atrophy on the formerly injured side and a slight tendency to subluxation of “drawer forwards” type.

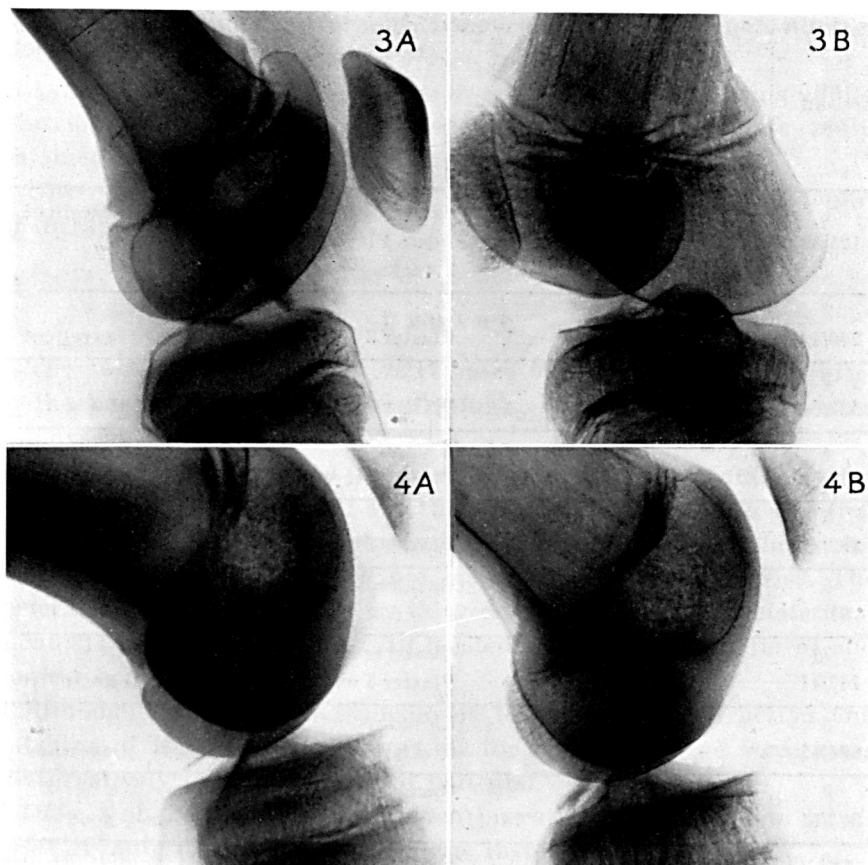
In the results of the review the 13 cases without any symptoms or signs are classified as excellent.

The 3 cases referred to above with slight symptoms possibly ascribable to the ligament injury have been classed in the table as good.

The results of the review are given in the table below.

#### CONCLUSIONS

As mentioned, any conclusions drawn must be seen against the background of the relative smallness of the series. It appears that total



*Fig. 3 A.*

Case 15. Rupt. of the ant. cruciate lig. in a ten years old girl. Before open reduction.

*Fig. 3 B.*

The same as 3 A. After open reduction.

*Fig. 4 A.*

Case 17. Rupt. of the post. cruciate lig. in a 14 years old boy on admission.

*Fig. 4 B.*

The same as 4 A. One year later at the review.

rupture of the medial collateral ligament is rare in childhood. The prognosis of partial rupture of this ligament is usually good and most of them are generally classed under the heading of "Distorsio gen.". The frequency of rupture of the anterior cruciate ligament in our material was higher than that generally seen in adult series. Furthermore the rupture in children occurs more often at the attachment on

Case record no.		Age in years	Interval between accident and admission (days)	Treatment	Interval between accident and review	Results
1 125/39	Rupt. coll. med.	10	17	Explor. without sutur. Plaster 2 weeks	16 years	excellent
2 240/42	„	12	5	Plaster 2½ weeks	13 years	excellent
3 438/51	„	12	1	Plaster 4 weeks	4 years	good
4 187/52	„	13	<1	Plaster 3½ weeks	3 years 1 month	excellent
5 393/47	Rupt. coll. lat.	13	14	Plaster 2½ weeks	8 years	excellent
6 61/38	Rupt. crus. ant.	15	7	Open reduction	17 years	
7 247/41	„	8	<1	Closed reduction Plaster 3 weeks	13 years	good
8 894/45	„	10	6	Closed reduction Plaster 6 weeks	9 years	excellent
9 973/51	„	9	12	Open reduction	2 years 9 months	good
10 624/52	„	12	<1	Open reduction	2 years	excellent
11 700/52	„	14		Closed reduction Plaster 6 weeks	2 years 1 month	excellent
12 1058/52	„	7	<1	Closed reduction Plaster 6 weeks	1 year 8 months	excellent
13 1455/52	„	8	<1	Closed reduction Plaster 6 weeks	1 year 6 months	excellent
14 772/53	„	8	5	Closed reduction Plaster 6 weeks	11 months	excellent
15 1345/53	„	10	<1		5 months	excellent
16 pol/54	„	8	4	Closed reduction Plaster 5 weeks	1 year 2 months	excellent
17 375/54	Rupt. crus. post.	14	3	Closed reduction Plaster 7 weeks	1 year	excellent

the tibia and assumes the form of "fracture of the tibial spine". Rupture of the axial ligament substance seems to be rare.

As to therapy we were more conservative than when treating adults. The closed reduction was always preferred, but if the immediate results obtained were unsatisfactory, arthrotomy was done.

Observations made at the review appeared to justify these principles of therapy.

#### SUMMARY

The author's series comprises 17 cases of fresh ligamental injuries to the knee joint in growing individuals, i.e., patients with residual epiphyseal cartilage.

A clear difference seems to exist between the ligamental injuries to the knee joint of the adult and those of the child in such a way that children exhibit isolated ruptures to a greater degree. Combined injuries in the strict sense did not occur in the author's series. The general picture is dominated by injuries to the anterior cruciate ligament (11 cases) and these are all located to the tibial attachment and possess bony fragments.

Although in adults the tendency is towards a reconstruction and suturing of the ligamental injury in the acute stage we were more conservatively minded with child patients.

Only 4 of the 17 cases were given operative treatment, and in all cases an anterior cruciate injury was involved.

The collateral ligamental injuries in this series were all of the partial type, localised to the femoral attachments. We did not see in a fresh condition any total injury of the type relatively common in adults. However, we encountered the residual condition of a non-treated injury to the medial collateral ligament with considerable consequences. This case is reported, but does not belong to the series.

Sixteen of the seventeen cases were followed-up and it was found that on isolated occasions one individual had very slight subjective discomfort from the injured knee when playing football, while the others declared themselves to be completely free from subjective trouble. In two cases a slight quadriceps atrophy was ascertained, and one of these two exhibited slightly increased "forward drawer" by comparison with the healthy side.

We interpreted the result to mean that it was correct to treat these injuries more conservatively in children than in adults.

## RESUME

Le matériel d'observation de l'auteur comprend 17 cas de lésions fraîches de ligaments du genou chez des individus à la période de la croissance, c'est-à-dire des malades ayant encore des cartilages épiphysaires.

Il semble y avoir une certaine différence entre les lésions des ligaments de l'articulation du genou chez l'adulte et chez l'enfant, c'est-à-dire que chez l'enfant on voit plus fréquemment des ruptures isolées.

Des lésions combinées proprement dites n'ont pas été constatées dans le matériel d'observation de l'auteur. Le tableau est dominé par les lésions du lig. cruciatum anterius (11 cas) et celles-ci ont toutes été localisées à la jointure du tibia avec fragments osseux.

Bien que la tendance, en ce qui concerne les adultes aille à l'encontre de la reconstruction et de la suture des lésions des ligaments à la phase aiguë, nous avons été plus conservateurs avec la clientèle enfantine.

4 seulement des 17 cas ont fait l'objet d'une intervention chirurgicale et il s'agissait dans tous les cas de lésions du cruciatum antérieur.

Les lésions du ligament collatéral ont toutes été, dans ce matériel d'observation du type partiel, localisé à l'attache du fémur. Nous n'avons pas constaté de lésions totales du type relativement courant chez les adultes dans les cas récents. Nous avons vu cependant les restes d'une lésion non traitée du ligament collatéral médial qui avait laissé des traces notoires. Ce cas est rapporté mais n'appartient pas au matériel d'observation.

16 cas, sur 17, ont été réexaminés et l'on a trouvé un cas isolé où le malade éprouvait un léger malaise subjectif dans le genou endommagé lorsqu'il jouait au foot bal. Les autres ont déclaré être subsubjectivement entièrement libres de toute gêne. Dans deux cas on a constaté une légère atrophie du quadriceps et chez l'un il y avait une traction légèrement supérieure en avant par comparaison avec le côté sain.

Ces résultats semblent donc démontrer que l'on est en droit d'appliquer un traitement plus conservateur de ces lésions chez les enfants que chez les adultes.

## ZUSAMMENFASSUNG

Das Material des Verfassers umfasst 17 Fälle von frischen Bandschäden im Kniegelenk bei Patienten im Wachstumsalter, welches besagt, dass die Epiphyse noch vorhanden war.

Es scheint ein gewisser Unterschied zwischen Bandschäden von Erwachsenen und Kindern zu bestehen derartig, dass Kinder häufiger isolierte Rupturen aufweisen. Kombinierte Schäden im eigentlichen Sinne kamen im Materiale des Verfassers nicht vor. Das Bild wird von Beschädigungen des lig. cruciatum anterius beherrscht (11 Fälle) und diese waren alle an der Tibia-Insertion lokalisiert und wiesen ein Knochenfragment auf.

Obwohl die Neigung besteht den akuten Schaden beim Erwachsenen mittels Rekonstruktion und Suturen zu behandeln, waren wir doch bei Kindern mehr konservativ eingestellt.

Nur 4 von den 17 Fällen wurden operativ behandelt und es drehte sich dabei ausschliesslich um vordere Kreuzbandschäden.

Sämtliche Seitenbandschäden in diesem Materiale waren nur von partieller Natur und entstanden an der Femurinsertion. Vollständige Schädigungen wie sie verhältnismässig häufig bei Erwachsenen vorkommen, haben wir in frischem Zustande nicht gesehen. Wir hatten dagegen einen Folgezustand nach unbehandelter Ruptur des medialen Seitenbandes mit erheblicher Dauerschädigung. Dieser Fall wird berichtet, aber er gehört nicht zum Materiale.

Sechzehn von den siebzehn Fällen wurden nachuntersucht und man fand, dass einer manchmal nur sehr leichte Beschwerden beim Fussballspielen von Seiten des geschädigten Knies hatte, während die übrigen subjektiv vollständig beschwerdefrei waren. In zwei Fällen konnte man eine leichte Quadricepsatrophie feststellen und einer von diesen zeigte ein leicht vermehrtes Schubladensymptom im Vergleich mit der gesunden Seite.

Wir haben das Untersuchungsergebnis in der Weise gedeutet, dass man berechtigt ist sich in der Behandlung dieser Schäden bei Kindern konservativer zu verhalten als bei Erwachsenen.

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