

Resection of the Infrapatellar Plica for Adolescent Anterior Knee Pain – Successful Treatment with Long-Term Follow-Up



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OBJECTIVE OF THE STUDY

This study demonstrates that arthroscopic release of the infrapatellar plica (IPP) can relieve the problem of adolescent anterior knee pain (AAKP) in pediatric patients not responding to conservative management.

BACKGROUND DATA

Adolescent Anterior Knee Pain (AAKP) is an unsolved problem affecting millions of children worldwide.

DEFINITION: a clinical syndrome in children characterized by mechanical pain perceived primarily at the front of the knee often associated with crepitation.

CHARACTERISTICS:

- **Onset:** insidious, or abrupt following trauma, or overuse
- **Course:** in most -- benign, and self-limited; in 25-45% pain becomes chronic, with long term sequelae; both physical and mental
 - Significant pain is ongoing ^{1,2,3}
 - Higher levels of mental distress, lower levels of self-perceived health ⁴
 - Child adopts the coping skills of chronic pain patients. ^{5,6}

BACKGROUND DATA AAKP

- **Chronic Result:** Secondary changes occur in entire limb due to loss of use; altered gait transforms the entire axis including the proximal core postural muscles
- **Physical Exam:** no consistent physical finding is diagnostic
 - No relationship to alignment or Q-angle
 - May have para-patellar tenderness or discomfort on direct pressure to the fat pad, especially if the examiner extends the knee at the same time
- **Investigations:** Plain films and MRI to rule out other pathology
- **Diagnosis:** is based on history and the absence of other definable pathology

MANAGEMENT: Generally conservative -- relative rest; analgesics/anti-inflammatories; brace/taping; physiotherapy (core and limb strengthening)

BACKGROUND DATA -- CURRENT TREATMENT APPROACH

THE QUANDRY: *What to do with the patient who fails conservative management?*

DO NOTHING HARMFUL: Tissue Homeostasis Approach (Dye)⁷

- avoid inciting activities, and try to achieve a pain-free, physiologic envelope of function through rehabilitation.

DO SOMETHING: There has been no “magic bullet” for the surgical treatment of AKP, and surgery may cause harm (Dye)⁷ The spectrum, based on structural alignment principles, or pain linked to overload of cartilage or bone, has included:

- Lateral release
- Realignment: proximal/distal
- Elevation/transfer tibial tubercle
- Articular cartilage procedures: shaving/drilling/microplasty/transplant
- Patellectomy

The disconnect is the patient who has mal-alignment or tight lateral retinaculum bilaterally, and pain in just one knee? Despite a myriad of theories, the anatomic basis for AAKP is not known. It remains the “Black Hole of Orthopaedics” (attributed to Wesley James).

Conservative management as above represents the current treatment philosophy.

BACKGROUND DATA-- DEVELOPMENT OF A NEW TREATMENT ALGORITHM

INDEX CASE: the idea of linking anterior knee pain to the IPP originated in 1991 with a fit 35 Y/O soldier with this problem, who faced release from the Canadian military.

- The onset was an abrupt increase in triathlon training. Completely normal physical exam. No change with 6 months of conservative management.
- Arthroscopy revealed inflammation at the femoral insertion of a large, separate infrapatellar plica (IPP). The knee was otherwise pristine.
- The IPP demonstrated non-isometric mechanical behavior, a change in tension as the knee was taken passively through its arc of motion, as follows:
 - IPP appeared lax in mid arc;
 - Became taut at the extremes of extension and flexion
 - Fat pad was held against the femur as the knee approached full extension, obscuring vision.
- This represented a new undocumented observation of non-isometric mechanical behavior of the IPP, considered an embryological remnant of no mechanical or clinical importance.^{8,9,10,11,12}
- IPP was released at the femoral insertion.
- Anterior knee pain resolved and patient returned to full duty as a paratrooper.

BACKGROUND DATA – NEW TREATMENT ALGORITHM

When faced with patients with established AAKP in 1993, the clinical author TVS, based on previous empirical success with adult military patients in Canada, instituted the following protocol.

CONSERVATIVE MANAGEMENT: minimum 3 months

IF SUCCESSFUL: continue strengthening the lower extremities and follow

IF NOT SUCCESSFUL:

- Exercise test: induce symptoms, inject dilute mix (5 cc 1/8% bupivacaine) in the symptomatic knee --
 - Complete relief of symptoms, consider arthroscopy
 - Minimal or no relief → continue conservative management

AT ARTHROSCOPY:

- Identify and treat all pathology; release the IPP at the femoral attachment, if present.
- No re-alignment, no lateral release.
- Chondral surfaces, if abnormal, debrided to stable margins.

MATERIALS AND METHODS

- The IRB at Upstate Medical University approved a retrospective cohort study:
 - All arthroscopic procedures in pediatric patients with procedure code of 29875 (partial synovectomy, release of IPP) performed by the clinical author (TVS) between 1993 and 2009.
 - 49 patients (18 and under) met the criteria; 35 could be contacted, and parents and child agreed to participate.
 - One patient had previous surgery for AAKP, a lateral release that had increased the level of her symptoms.
 - No case included chondral erosion to bone. Abnormal chondral surfaces were noted, debrided where deemed appropriate, and included in the study as Dye has documented that such surfaces are asymptomatic.¹³

MATERIALS AND METHODS

- The treatment approach was as outlined above. For patients who failed, informed consent for arthroscopy was offered to the child and parent(s), based on:
 - Probability of continuing symptoms (25 - 40%) ^{1,2,3,4,5,6}
 - Exercise test (offered to all, performed in 10 knees)
 - Risks and benefits of arthroscopic evaluation: “...Paediatric knee arthroscopy is a safe procedure that significantly improves the accuracy of clinical diagnosis, allows the definitive treatment of a variety of conditions...” ¹⁴
- Outcome measurements included standardized subjective knee scales: the Lysholm Scale (LS) ¹⁵ and the Activities of Daily Living Scale of the Knee Outcome Survey (ADLS) ¹⁶ accessed through a secure website (anteriorkneepain.com). The follow-up period was from 11 months to 180 months, with a mean of 64 months. The ADLS scale of 80 points was converted to 100 to allow comparison with the Lysholm scale.

MATERIALS AND METHODS

- **Participants:** 23 females, 12 males, with 14 patients undergoing bilateral procedures.
- **Mechanism of onset:**
 - **AAKP after acute injury -** 16 knees, 14 patients - 2 bilateral
 - **AAKP with insidious onset -** 22 knees, 15 patients - 8 bilateral
 - **AAKP after overuse -** 11 knees, 8 patients - 3 bilateral

NB: 2 patients with bilateral symptoms were in 2 groups, one knee in the insidious group, the other knee in the overuse group accounting for the discrepancy in patient #s

- **Knee Distribution:** 28 Right, 21 Left
- **Mean age at presentation:** 16.5 years (range 9 - 18)

MATERIALS AND METHODS

- **Average duration of symptoms:** 28 months (range 4 - 96)
- **Average time post surgery till review:** 64 months (range 6 – 180)
- **Pain distribution: there is wide variation in the presenting complaint and in the nature of the pain described –**
 - Parapatellar deep ache
 - Location anywhere -- deep, medial, lateral or posterior
 - Snapping, popping, and crunching
 - Giving way often present
 - When symptoms are severe, the pain can be constant, and unrelenting
- **Physical exam:** There were no diagnostic findings. Extension loss was not present in any patient. Fat pad tenderness was almost universal. Crepitus often present. ROM normal. True effusion rare (2/49). Exercise test positive in 8, some relief in 2.

MATERIALS AND METHODS

SURGICAL OBSERVATIONS:

■ Plica anatomy (Classification from Kim)¹⁷:

- All knees had an infrapatellar plica except one where the IPP had been torn
- Distribution was: 25 separate ; 12 split; 6 fenestra; 5 vellum; 1 torn

■ Plica morphology:

- **21 knees:** IPP - normal morphology; that is, no scarring, or contracture
- **1 knee:** IPP torn, probably during insertion of the scope
- **6 knees:** abnormalities of the IPP (inflammation or fraying) or the immediately adjacent CB and FP (fraying or inflammation) – all in acute injury group

NB: See Discussion and Conclusions. The anatomical site of AAKP is the FP and IPP/CB complex. Prolongation of pain is from their physiology and is not from abnormal morphology, as in the described sequence of repetitive trauma, inflammation and loss of elasticity leading to the medial plica syndrome .

MATERIALS AND METHODS

- **Additional findings at surgery:**
 - **5 knees:** medial plica was removed if contact with medial femoral condyle was observed
 - **7 knees:** CMP was present; chondroplasty performed in 2
 - **2 knees:** small loose bodies, fibrous or cartilagenous, no obvious source
 - **3 knees:** anomalous bands in the notch, not part of the IPP; these were removed
 - **1 knee:** discoid lateral meniscus, partial resection
 - **6 knees:** notch demonstrated a groove in which the IPP slid approaching full extension; implies regressive remodeling secondary to mechanical force
 - **1 knee:** no history of trauma, small lateral meniscal tear, debrided
- **Complications:** There was recurrence of pain in 3 patients, 5 knees (2 with bilateral symptoms). No other complications occurred.

RESULTS

The clinical results were as follows: from pre-op to post-op, mean Lysholm scores improved from 40 (SD 16; range 15 -85) to 84 (SD 15; range 36 - 100) and mean ADLS scores improved from 45 (SD 16; range 20 - 72) to 70 (SD 12; range (34 - 80).

- ***Repeated measures ANOVA showed that these improvements were highly significant ($p<0.0001$) and that there were no significant differences in these improvements between injury mechanism groups ($p=0.55$).***

Charts on the next 3 slides outline the data on each of the subcategories of AAKP: after acute injury, of insidious onset, and in association with overuse. The ADLS score was converted to a percentage to allow easier comparison with the Lysholm scale.

The ADLS percentage score as used to grade the results as follows:

Excellent (E) – 90 to 100; Good (G) - 80 to 89; Fair (F) – 70 to 79; Poor (P) – 69 or below.

AAKP AFTER ACUTE INJURY SUBGROUP: DATA AND RESULTS

| Patient Number | Age at Onset | Knee Number | Side | Duration Months | IPP Type | Structure | Additional Findings | Procedure | Follow Up Months | Lysholm | ADLS | Assessment |
|----------------|--------------|-------------|-------|-----------------|----------|--------------------|--------------------------|----------------|------------------|---------|------|------------|
| 8 | 14 | 10 | Left | 7 | Split | Fibrous | Medial plica | Removal IPP/MP | 148 | 95 | 100 | E |
| 9 | 13 | 11 | Right | 4 | Split | Fibrous | Infl IPP, marked fraying | Removal IPP | 11 | 100 | 100 | E |
| 13 | 16 | 17 | Left | 5 | Separate | Fibrous | IPP thickened, Infl | Removal IPP | 161 | 90 | 93 | E |
| 19 | 14 | 26 | Left | 7 | Separate | Fibrous | | Removal IPP | 108 | 91 | 90 | E |
| 21 | 15 | 28 | Right | 6 | Separate | Fibrous | FP fraying CB | Removal IPP | 39 | 91 | 96 | E |
| 24 | 16 | 33 | Right | 24 | Split | Fibrous | | Removal IPP | 17 | 90 | 94 | E |
| 25 | 17 | 34 | Left | 26 | Separate | Fibrocartilagenous | | Removal IPP | 84 | 95 | 100 | E |
| 26 | 18 | 35 | Right | 6 | Separate | Fibrous | | Removal IPP | 144 | 90 | 96 | E |
| 28 | 14 | 37 | Right | 12 | Split | Fibrous | Fraying IPP | Removal IPP | 6 | 95 | 99 | E |
| 35 | 12 | 48 | Right | 7 | Separate | Fibrocartilagenous | Loose body | Removal IPP | 81 | 85 | 99 | E |
| 35 | 12 | 49 | Left | 7 | Separate | Fibrous | Fraying/inflammation FP | Removal IPP | 81 | 85 | 99 | E |
| | | | | | | | Patella chondral crack | | | | | |
| 3 | 9 | 3 | Left | 34 | Fenestra | Fibrous | Inflammation FP | Removal IPP | 120 | 81 | 86 | G |
| 22 | 15 | 29 | Right | 13 | Separate | Fibrous | CMP(minimal) | Removal IPP | 10 | 86 | 89 | G |
| 22 | 15 | 30 | Left | 13 | Fenestra | Fibrous | CMP(minimal) | Removal IPP | 10 | 86 | 89 | G |
| 27 | 17 | 36 | Right | 7 | Vellum | Fibrous | | Removal IPP | 149 | 61 | 80 | G |
| 1 | 12 | 1 | Right | 24 | Separate | Fibrocartilagenous | IPP and CB inflammation | Removal IPP/MP | 65 | 42 | 43 | P |

LEGEND: Infrapatellar Plica = IPP; Medial Plica = MP; Fat Pad = FP; Lateral meniscectomy (partial) = LM; Good = G; Excellent = E; Fair = F; Poor = P

OUTCOMES FOR ACUTE INJURY SUBGROUP: 16 knees, 14 patients

- **Knees:**
 - Good or excellent: 15/16, or 94% of knees
 - Fair: none
 - Poor: 1/16, or 6%
- **Patients:**
 - Good or excellent: 13/14, or 93% of patients

AAKP - INSIDIOUS ONSET SUBGROUP: DATA AND RESULTS

| Patient Number | Age at Onset | Knee Number | Side | Duration Months | IPP Type | Structure | Additional Findings | Procedure | Follow Up Months | Lysholm | ADLS | Assessment |
|----------------|--------------|-------------|-------|-----------------|----------|--------------------|-------------------------|------------------------------|------------------|---------|------|------------|
| 5 | 12 | 6 | Right | 36 | Separate | Fibrous | | Removal IPP | 21 | 94 | 94 | E |
| 7 | 14 | 9 | Right | 48 | Torn | Fibrous | | Removal IPP, trimming of FP | 72 | 79 | 91 | E |
| 11 | 18 | 13 | Right | 96 | Split | Fibrous | Anomalous lateral band. | Removal IPP/LM | 96 | 100 | 100 | E |
| 11 | 10 | 14 | Left | 96 | Split | Fibrous | Notch - groove | Removal IPP | 3 | 100 | 100 | E |
| 18 | 16 | 24 | Left | 84 | Split | Fibrous | | Removal IPP | 84 | 86 | 98 | E |
| 18 | 16 | 25 | Right | 84 | Split | Fibrous | | Removal IPP | 82 | 86 | 98 | E |
| 20 | 11 | 27 | Left | 36 | Fenestra | Fibrocartilagenous | | Removal IPP | 41 | 91 | 95 | E |
| 29 | 18 | 38 | Right | 22 | Separate | Fibrous | | Removal IPP | 60 | 91 | 98 | E |
| 29 | 18 | 39 | Left | 12 | Separate | Fibrous | | Removal IPP | 60 | 91 | 99 | E |
| 30 | 12 | 40 | Right | 24 | Separate | Fibrous | CMP w adj MP | Removal IPP/MP/Chondroplasty | 28 | 91 | 96 | E |
| 30 | 12 | 41 | Left | 24 | Separate | No data | | Removal IPP | 25 | 91 | 96 | E |
| 34 | 13 | 47 | Right | 48 | Separate | Fibrous | | Removal IPP | 48 | 85 | 85 | G |
| 4 | 12 | 4 | Right | 14 | Separate | Fibrous | Notch - groove | Removal IPP | 60 | 81 | 80 | G |
| 6 | 15 | 7 | Left | 24 | Split | Fibrous | 3 small loose bodies | Removal IPP | 55 | 80 | 86 | G |
| 10 | 15 | 12 | Right | 39 | Separate | Fibrous | | Removal IPP | 40 | 70 | 83 | G |
| 31 | 13 | 42 | Right | 9 | Fenestra | Fibrous | Mild CMP | Removal IPP | 24 | 85 | 84 | G |
| 31 | 13 | 43 | Left | 9 | Separate | Fibrous | | Removal IPP | 24 | 85 | 84 | G |
| 32 | 10.5 | 44 | Right | 18 | Vellum | Fibrous | | Removal IPP/MP | 6 | 74 | 78 | F |
| 15 | 18 | 19 | Left | 84 | Split | Fibrous | Notch - groove | Removal IPP | 60 | 45 | 44 | P |
| 15 | 18 | 20 | Right | 84 | Split | Fibrous | Notch - groove | Removal IPP | 60 | 36 | 43 | P |
| 17 | 12 | 22 | Right | 20 | Separate | Fibrous | CMP | Removal IPP/Chondroplasty | 33 | 45 | 45 | P |
| 17 | 12 | 23 | Left | 20 | Separate | Fibrous | | Removal of IPP | 36 | 45 | 45 | P |

OUTCOMES FOR INSIDIOUS ONSET SUBGROUP: 22 knees, 15 patients

- **Knees:**
 - Good or excellent: 17/22, or 77% of knees
 - Fair: 1/22, or 5% of knees
 - Poor: 4/22, or 18% of knees
- **Patients:**
 - Good or excellent: 12/15, or 80% of patients
 - Fair: 1/15, 7%; Poor – 2/15, 13%

AAKP - OVERUSE SUBGROUP: DATA AND RESULTS

| Patient Number | Age at Onset | Knee Number | Side | Duration Months | IPP Type | Structure | Additional Findings | Procedure | Follow Up Months | Lysholm | ADLS | Assessment |
|----------------|--------------|-------------|-------|-----------------|----------|--------------------|-----------------------|----------------------------|------------------|---------|------|------------|
| 2 | 13 | 2 | Right | 4 | Separate | Fibrous | Notch - groove | Removal IPP/MP | 11 | 76 | 95 | E |
| 5 | 12 | 5 | Left | 36 | Separate | No data | | Removal IPP | 77 | 94 | 94 | E |
| 6 | 15 | 8 | Right | 24 | Split | Fibrous | CMP | Removal IPP/Chondroplasty | 55 | 100 | 99 | E |
| 23 | 10 | 31 | Left | 8 | Vellum | Fibrous | Discoid LM | Removal IPP/LM | 77 | 99 | 98 | E |
| 23 | 10 | 32 | Right | 8 | Vellum | Fibrocartilagenous | Several fibrous bands | Removal IPP/MP | 18 | 99 | 98 | E |
| 33 | 9 | 45 | Right | 36 | Fenestra | Fibrous | | Removal IPP | 72 | 100 | 96 | E |
| 33 | 9 | 46 | Left | 36 | Fenestra | Fibrous | Notch - groove | Removal IPP | 72 | 100 | 96 | E |
| 12 | 16 | 15 | Right | 36 | Separate | No data | | Removal IPP | 180 | 90 | 88 | G |
| 12 | 16 | 16 | Left | 36 | Separate | No data | | Removal IPP | 180 | 90 | 88 | G |
| 14 | 17 | 18 | Left | 14 | Vellum | Fibrous | Fibrosis FP | Removal IPP | 36 | 79 | 71 | F |
| 16 | 9 | 21 | Right | 19 | Separate | Fibrous | Anomalous band | Removal IPP/Anomalous Band | 101 | 69 | 73 | F |

OUTCOMES FOR OVERUSE SUBGROUP: 11 knees, 8 patients

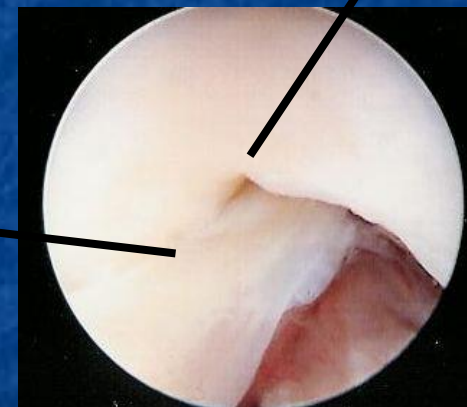
• Knees:

- Good or excellent: 9/11, or 82% of knees
- Fair: 2/11, 18%; Poor: none

• Patients:

- Good or excellent: 6/8 or 75%
- Fair: 2/8 or 25%

IPP FBC appearance



IPP STRUCTURE AND ADDITIONAL FINDINGS

- A groove was present in the articular cartilage at the apex of the notch in 6 cases
- The superior surface of the IPP had a fibrocartilagenous (FBC) appearance in 5 cases

DISCUSSION AND CONCLUSIONS

The hypothesis arising from observing the IPP arthroscopically, is as follows:

- The IPP acts as a non-isometric intra-articular ligament, tethering the pain sensitive fat pad at the central body.
- With motion, the FP rotates around the IPP insertion, a center of rotation that is not that of the knee.
- Motion thus imparts stretch and relaxation to the IPP, and CB, at the extremes of flexion and extension.
- The tethered FP deforms as well, as a result of the mechanical behavior of the IPP.

The clinical observation made by others, anecdotally^{18,19,20} is that anterior knee pain is relieved by releasing the IPP at its femoral attachment.

- This study in 35 patients and 49 knees confirms this, with highly significant improvement in knee function demonstrated with both the Lysholm and ADKS scores, with long term follow-up.
- There were no complications. All patients but one improved. No patient was made worse.

Our group has reported anatomic, histologic, and radiologic data in cadavers supporting the hypothesis. As well, an IRB study in human volunteers demonstrated radiographically the stretch and deformation of the IPP, CB and FP,²¹ confirming the original arthroscopic observations. The FP and CB are highly innervated,²¹ pain sensitive structures.¹³

These studies also confirm that release of the IPP at the femoral insertion eliminates the mechanical perturbation on the IPP. Pain relief may be due to this, or to denervation.

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