CANADIAN THESES

THÈSES CANADIENNES

TC –

0-315-23271-4

CANADIAN THESES ON MICROFICHE SERVICE – SERVICE DES THÈSES CANADIENNES SUR MICROFICHE

PERMISSION TO MICROFILM – AUTORISATION DE MICROFILMER

• Please print or type – Écrire en lettres moulées ou dactylographier

AUTHOR – AUTEUR

Full Name of Author – Nom complet de l'auteur

Joan Montgomery Wilson

Date of Birth – Date de naissance

July 7, 1958

Canadian Citizen – Citoyen canadien

☑ Yes Oui ☐ No Non

Country of Birth – Lieu de naissance

Canada

Permanent Address – Résidence fixe

#2201, 11135 83 Avenue
Edmonton, Alberta
T6G 2C6

THESIS – THÈSE

Title of Thesis – Titre de la thèse

Intraosseous Venous Pressures of the Patella in Chondromalacia Patellae

Degree for which thesis was presented
Grade pour lequel cette thèse fut présentée

M.Sc

Year this degree conferred
Année d'obtention de ce grade

1985

University – Université

University of Alberta

Name of Supervisor – Nom du directeur de thèse

Dr. D.J. Magee

AUTHORIZATION – AUTORISATION

Permission is hereby granted to the NATIONAL LIBRARY OF CANADA to **microfilm** this thesis and to **lend** or **sell copies of the film.**

The author reserves other publication rights, and neither the thesis nor extensive extracts from it may be printed or otherwise reproduced without the author's written permission.

L'autorisation est, par la présente, accordée à la BIBLIOTHÈQUE NATIONALE DU CANADA de **microfilmer** cette thèse et de **prêter** ou de **vendre des exemplaires du film.**

L'auteur se réserve les autres droits de publication; ni la thèse ni de longs extraits de celle-ci ne doivent être imprimés ou autrement reproduits sans l'autorisation écrite de l'auteur.

ATTACH FORM TO THESIS – VEUILLEZ JOINDRE CE FORMULAIRE À LA THÈSE

Signature

Joan Wilson

Date

October 9, 1985

THE UNIVERSITY OF ALBERTA

INTRAOSSEOUS VENOUS PRESSURES OF THE PATELLA IN CHONDROMALACIA PATELLAE

by

© JOAN MONTGOMERY WILSON

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF PHYSICAL THERAPY

EDMONTON, ALBERTA

FALL 1985

THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR JOAN MONTGOMERY WILSON

TITLE OF THESIS INTRAOSSEOUS VENOUS PRESSURES OF THE PATELLA IN CHONDROMALACIA PATELLAE

DEGREE FOR WHICH THESIS WAS PRESENTED MASTER OF SCIENCE

YEAR THIS DEGREE GRANTED FALL 1985

(SIGNED) ....

PERMANENT ADDRESS:

#2201, 11135 83 Avenue

Edmonton, Alberta

T6G 2C6

DATED 19 85

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled INTRAOSSEOUS VENOUS PRESSURES OF THE PATELLA IN CHONDROMALACIA PATELLAE submitted by JOAN MONTGOMERY WILSON in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE.

....
Supervisor

....

....

....

Date....September 24, 1985.....

DEDICATION

To my parents, who taught me to always give
my best effort regardless of the level
or actions of the opposition.

ABSTRACT

The purpose of this study was to assess the difference in the intraosseous venous pressure of the patella between grades of articular cartilage degeneration as well as to compare selected pre-surgery signs and symptoms with the above two variables. The investigation was designed as a prospective study examining patients of one orthopaedic surgeon at the University of Alberta Hospital. One group consisted of twenty-four patients who were having surgery for the retropatellar pain syndrome, while the comparison group was made up of twenty-four patients undergoing meniscal or ligamentous surgery.

A one-way ANOVA was used to examine the difference in the intraosseous venous pressure between : 1) grades of cartilage degeneration, 2) the levels of the alignment variables, 3) the levels of severity of crepitus, and the difference in the quadriceps angle between the grades of cartilage degeneration. The relationship between the quadriceps angle and the intraosseous venous pressure was examined using a Pearson Product Moment Correlation Coefficient. The difference in the intraosseous venous pressure between groups with and without the other signs and symptoms was analysed using Student's t-tests. The frequencies of all the signs and symptoms were compared to the presence or absence of cartilage degeneration with Chi-square tests.

In accordance with the limitations and delimitations imposed on this study, the intraosseous venous pressure of the patella did not prove to be significantly different between grades of cartilage degeneration or different between the groups with or without any of the clinical signs and symptoms examined.

The existence of patellar cartilage degeneration compared to the following symptom and sign at the .05 level of significance : 1) the frequency of occurrence of pain experienced while ascending or descending stairs, and 2) the frequency of pain with patellar compression at twenty degrees of knee flexion. The severity of crepitus during both passive and resisted movement proved to be significant at the .01 and .05 level of confidence respectively when compared to the frequency of occurrence of cartilage degeneration.

It was concluded that the intraosseous venous pressure of the patella is not significantly different between grades of cartilage degeneration. Intraosseous venous pressure of the patella is not significantly different between groups with and without rest pain. Few of the signs and symptoms reported in the literature help differentiate between other knee pathology and true chondromalacia patellae.

ACKNOWLEDGEMENTS

The completion of this thesis would not have transpired had it not been for the advice and support of many individuals. I would like to express my sincere thanks to:

Dr. David Magee, my advisor, who provided advice and guidance throughout the length of the study;

Dr. David C. Reid for his endless support, encouragement, and guidance throughout the length of the study as well as for providing access to his patients, performing the intraosseous venous pressure measurements, and assisting with the illustrations;

My committee members, Dr. Donna Ford for her helpful advice and to Dr. Jim Vargo for his time and advice on data analysis;

Dr. John Kramer for his many suggestions and advice throughout the study;

Dr. Shrawan Kumar for his valuable suggestions in the preliminary stages of this study;

Kaye Reid for her expert advice and her time devoted to the reliability testing for blood pressure measurement;

Judy Jowarski and Evelyn Wampler for their patience and time in obtaining the patient list each week of the study;

Keith Bowker for his time and assistance in organizing the intraosseous venous pressure measurement apparatus;

The Operating Room staff at the University of Alberta Hospital, in particular Nancy Bevan and Ann Toller for their

assistance with equipment and personnel;

The orthopaedic residents working with Dr. Reid during the study, the nursing staff on Stations 46, 47 and 57, and the Physiotherapy Department in the University Hospital for their cooperation.

Table of Contents

List of Tables

Table		Page

List of Figures

List of Abbreviations

IOVP	-	Intraosseous Venous Pressure
IOVP/MAP x 100	-	Percentage that the IOVP is of the Mean Arterial Blood Pressure
PFC	-	Presence of Patellar Cartilage Degeneration
G of PFC	-	Grade of Patellar Cartilage Degeneration
ROM	-	Range of Motion
Q-angle	-	Quadriceps Angle
mm Hg	-	Millimeters of Mercury
ANOVA	-	Analysis of Variance
SD	-	Standard Deviation
χ^2	-	Chi-square

Chapter I

THE PROBLEM

A. Statement of the Problem

Chondromalacia patellae is a frequent clinical diagnosis in patients suffering from retropatellar pain. Despite the numerous publications concerning chondromalacia patellae, the diagnostic criteria are still open to much debate. Furthermore, the basic etiology and natural history of the disease is a subject of controversy[1,2]. Further knowledge regarding the pathophysiology is necessary to permit accurate diagnosis and the establishment of the correct treatment. This knowledge will contribute to the cost-effectiveness of medical care for the numerous patients with chondromalacia patellae.

It has been suggested that venous engorgement, and the resultant intraosseous hypertension, play a significant role in the etiology of pain in osteoarthritis[3,4,5]. Although numerous studies have demonstrated increased intraosseous pressure in cancellous bone adjacent to weight bearing joints with osteoarthritis, only one study[6] has investigated this aspect in chondromalacia patellae and patello-femoral osteoarthrosis.

Bjorkstrom et al.[6] found the mean patellar intraosseous pressure in chondromalacia patellae subjects (n=13) to be 44 mm Hg (range 21-84) and in three subjects with patellar osteoarthritis the mean pressure equalled 37 mm Hg (range

15-74). The comparison group in their study consisted of menisectomy patients who had a mean pressure of 15 mm Hg (range 4-42, n=9). No statistical analysis was performed on these results by Bjorkstrom et al.[6]. Ficat and Hungerford[7] estimate the intraosseous pressure of the normal patella to be 10-15 mm Hg. They do not report pressures in chondromalacia patellae, but mention that in a condition they call "reflex sympathetic dystrophy" of the knee, intraosseous pressures of the affected patellae were in the range of 30-50 mm Hg.

Waisbrod and Treiman[8] demonstrated with phlebography that the venous engorgement in chondromalacic patellae is indistinguishable from that of patellae with osteoarthritis.

Bjorkstrom and Goldie[9] examined patellae from six amputated limbs and fifteen autopsy specimens and found that the arteries in the subchondral bone were wider and more tortuous deep to areas of degenerative cartilage. However, in patellae with normal cartilage (n=9), increasing age appeared to cause a narrowing of the arteries. The age of specimens in their study ranged from 17 to 70 with a mean age of 34. Six of the specimens had chondromalacia patellae and six others had osteoarthritis. The investigators also noted that this arterial variation was more pronounced in specimens in which the cartilage degeneration was worse. It has been suggested that the increased caliber of these vessels is a result of the back pressure produced by impaired venous drainage[4]. However, the reason for the impaired venous drainage has not been determined.

Radin[2] suggested that microfractures of the trabeculae occur in the subchondral bone when the joint is overloaded, either by repetitive loading resulting in fatigue fracture or by a single stress incident. Furthermore, he suggested that the healing of these microfractures caused blockage of normal routes of venous drainage. It has been demonstrated in animal studies[10] that chronic venous congestion can produce an increase in the trabeculation of bone. Hence, once the initial blockage occurs then a self-sustaining cycle may develop.

Townsend[11] proposed that the increase in trabeculation would cause the subchondral bone to be less resilient, thus exposing the overlying articular cartilage to greater stresses with joint loading. According to the biomechanical study performed on cartilage by Weightman et al.[12], this increased stress could easily overload the physiological capabilities of the cartilage and cause it to degenerate.

There have been many studies[3-10] on blood circulation in bone since 1876 when the first study was done by Langer[13]. Several of these studies[8,9,13] have been limited to bone morphology and the physiologic, or dynamic, aspects of bone circulation have not received the same amount of attention. Because of the extreme complexity of blood channels in cancellous bone and the multiple inflowing and outflowing of minute vessels through the bone cortex, the method of investigation is quite difficult. However, since the cancellous bone and its circulation may be considered to be contained within a semiclosed space, the intraosseous pressure may be used as an indirect indicator of the dynamics of bone circulation[14].

In summary, the dilemma of the chondromalacia patellae pain syndrome is that it has several etiologies and some of these are ill-defined. From the results of studies by Bjorkstom et al.[4], Waisbrod et al.[8], and Bjorkstrom et al.[7], there is a suggestion that the state of patellar cartilage degeneration may be related to the extent of intraosseous pressure changes. Since in osteoarthritis, pain at rest has been mentioned as a symptom of venous engorgement (intraosseous hypertension)[3,4] perhaps this type of pain is also indicative of engorgement of the patellae in chondromalacia patellae. Hence, a specific clinical subtype of retropatellar pain involving intraosseous circulation may exist, but has not been investigated.

B. Objective of the Study

The objective of the study was to analyse the intraosseous venous pressure of patellae in forty-eight patients with reference to pre-surgery signs and symptoms and the presence or absence of cartilage degeneration on the retropatellar surface of the patellae.

C. Research Hypotheses

The research hypotheses of the study were :

1. The intraosseous venous pressure of the patellae will be greater in the cases demonstrating more severe grades of chondromalacia patellae.
2. Patients who complain of aching pain at rest regardless of the position of the knee will demonstrate higher intraosseous venous pressure of the patella than those patients who do not have this symptom.
3. Patients with signs and symptoms reported in the literature to indicate the presence of chondromalacia patellae will demonstrate a higher incidence of chondromalacic changes than those patients who do not have these specific signs and symptoms.

D. Significance of the Study

Waisbrod and Treiman[8] mention that drilling holes in patellae with early chondromalacia patellae may relieve the venous congestion. These researchers are now attempting to determine the effectiveness of this procedure in relieving pain. Ficat and Hungerford[7] suggest that "core decompression" reduces the intraosseous pressure of the patella and results in a decrease in the pain experienced by their reflex sympathetic dystrophy patients. Unfortunately, they provide no description of their "core decompression" procedure. If these two procedures do relieve the venous congestion, and subsequent pain, in some cases but not in others[7], perhaps there are certain types, or stages of chondromalacia patellae that would benefit from this procedure and others that would not. Should the patients who would benefit from decompression form a group with specific clinical signs and symptoms, the sometimes lengthy and unsuccessful physiotherapy treatment of some of these patients might be avoided. If such a group exists, the surgeon might consider fenestration as the treatment of choice.

E. Definition of Terms

1. **Clicking** - Audible noise heard by the patient during movement and perceived to be in the knee joint.

2. **Catching** - The knee momentarily stops at one point in the range during active movement. This stoppage may or may not produce pain.

3. **Locking** - The knee remains stuck in one position despite attempts to move the joint.

4. **Giving Way** - The knee buckles during weight bearing. The patient does not necessarily fall.

5. **Activity Pain** - Diffuse or specific discomfort felt in the anterior aspect of the knee during the following situations :

a. Stair Climbing - during ascending or descending a flight of stairs.

b. Sitting with knees flexed - after sitting in this position for any length of time greater than five minutes.

c. Following activity - such as walking, running, cycling, hiking, or climbing.

6. **Rest Pain** - Aching, throbbing discomfort experienced when not moving or weight bearing and not alleviated by changes of knee position. This pain is recorded as occurring during the day or during the night.

7. **Alignment** -

a. Varus (Figure 1) The position for varus measurement was with the patient standing with the feet together and the medial borders of the feet parallel. The following terms were used to delineate the amount of varus :

1) None - Knees touch each other.
2) Mild - 1 - 5.0 centimeters between knees.
3) Moderate - 5.1 - 7.5 centimeters between knees.
4) Severe - 7.6 centimeters or more between knees.

b. Valgus (Figure 2) The position for valgus measurement was with the patient standing with the knees together and the medial borders of the feet

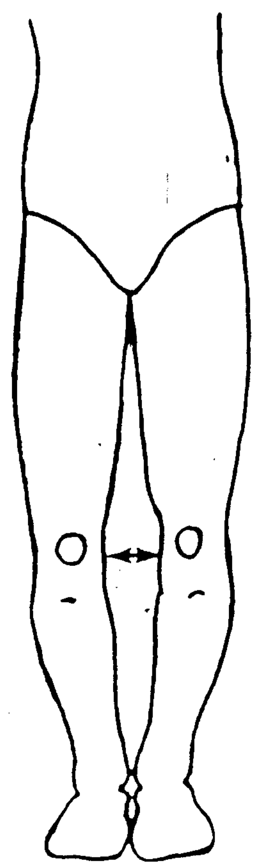


Figure 1. Position for measurement of varus alignment. The distance between the knees was measured with the medial borders of the feet touching.

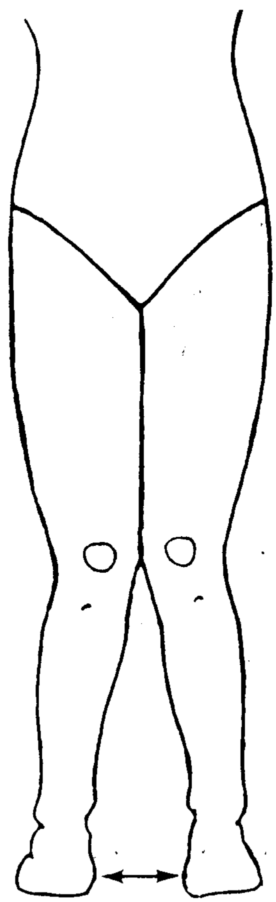


Figure 2. Position for measurement of valgus alignment. The distance between the medial borders of the feet was measured with the knees touching.

parallel. The following terms were used to delineate the amount of valgus :

1) None - Medial borders of feet touch.
2) Mild - 1 - 5.0 centimeters between medial borders of feet.
3) Moderate - 5.1 - 7.5 centimeters between medial borders of feet.
4) Severe - 7.6 centimeters or more between medial borders of feet.

c. Recurvatum (Figure 3) - Both knees were actively hyperextended while the patient was standing with the feet together. The angle of hyperextension was measured using the lateral epicondyle of the femur as the axis with the two distant points of reference being the greater trochanter proximally and the lateral malleolus distally. The following were used to delineate the amount of recurvatum :

1) None - 0 degrees
2) Mild - 1 - 5 degrees
3) Moderate - 6 - 10 degrees
4) Severe - 11 degrees or more

d. Rotation (Figure 4) - With the patient standing relaxed with the feet (or the knees in the cases of valgus) together, the leg was rotated to the position where the medial and lateral borders of the patella were in the coronal plane. The measurement was then performed with a goniometer to determine

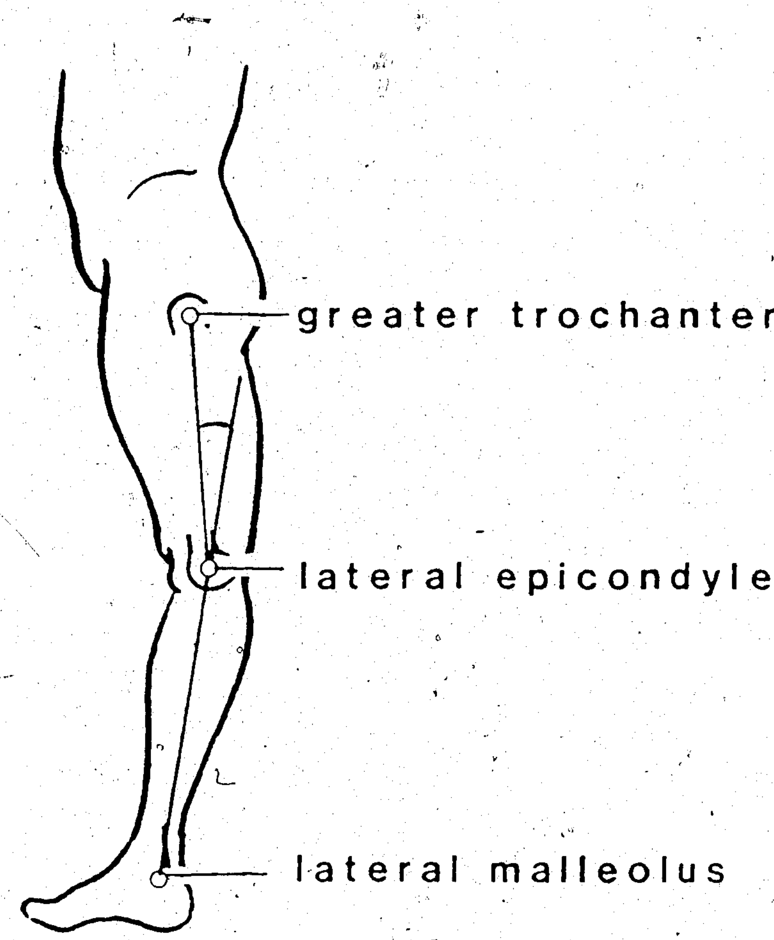


Figure 3. Position for measurement of recurvatum alignment. The angle was formed by the greater trochanter and the tip of the lateral malleolus acting as the proximal and distal reference points with the lateral epicondyle of the femur forming the axis.

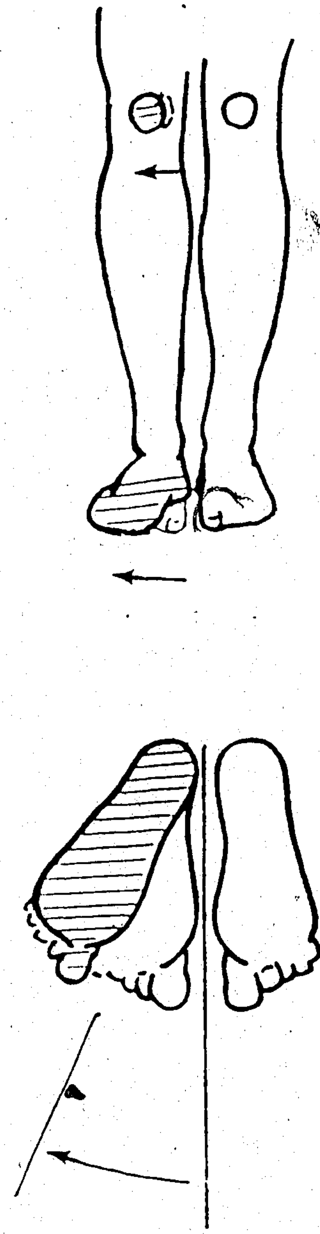


Figure 4. Position for measurement of rotation. The leg was rotated to a position where the medial and lateral edges of the patella were in the coronal plane. The angle between the midline and the medial border of the foot was measured.

the angle of the medial borders of the feet with respect to the sagittal plane. The following were used to delineate the amount of rotation :

1) None - 0 degrees
2) Mild - 1 - 5 degrees
3) Moderate - 6 - 10 degrees
4) Severe - 11 degrees or more

Medial - Toes pointing toward midline

Lateral - Toes pointing away from midline

8. **Pain on Patellar Compression** - With the patient positioned in lying, the knee was placed in either twenty or zero degrees of flexion and the examiner exerted 5 to 7 kilograms pressure on the patella to produce increased contact pressure between the patella and the trochlear surface of the femur. The patella was then rocked medio-laterally and proximo-distally on the trochlea. If the patient experienced pain or discomfort the test was positive. Twenty degrees of flexion was achieved by placing the examiner's forearm under the patient's knee. Approximately zero degrees of knee flexion was achieved by the patient relaxing his or her leg on the bed. These two positions were chosen to match the positions for Clarke's Sign.

9. **Clarke's Sign or the Dynamic Patellar Compression Test**

The examiner used the webspace between the thumb and index finger to push the patella distally into the trochlear groove while the patient was relaxed[15]. While the examiner maintained downward and distal pressure at the base of the patella, the patient was requested to slowly tighten his/her quadriceps. The test was considered positive if the patient experienced pain or disco[illegible]. The positioning was the same as for the retropatellar compression test at 20 and 0 degrees. Twenty degrees was the most flexed position chosen due to practical difficulties encountered in performing this test at greater angles of flexion when the patella began to sit deeper in the trochlear groove.

10. **Effusion** -

a. <u>None</u> - No test for excess fluid in the knee joint was positive.

b. <u>Mild</u> - This grade was given if a positive test for subtle knee joint effusion[16] was present and neither of the tests for moderate or severe effusions were positive. The test for subtle effusion was performed by positioning the knee in relaxed supported extension and stroking the antero-medial aspect of the knee in a proximal direction. This maneuver was followed by stroking the suprapatellar pouch and antero-lateral aspect of the joint in a distal direction. This test was positive if a bulge of fluid appeared medial to the patella at the joint line.

c. Moderate - If a positive ballotement of the patella was detected only when the suprapatellar pouch was compressed by the examiner's hand, the effusion was graded in this category. The ballotement was detected by pushing the patella down onto the femoral trochlea with one or two fingers. If the patella floated prior to tapping or knocking against the femur the test was considered to be positive.

d. Severe - If a positive ballotement was detected without compressing the suprapatellar pouch, then the effusion was graded in this category.

11. **Quadriceps Angle** (Figure 5) - The patient was positioned supine in the anatomic position with the medial borders of the feet touching. This position of the patient's leg was maintained by the examiner so that the quadriceps were relaxed. A long-arm goniometer was used with the center of the patella marking the axis. The two distant points of reference were the anterior superior iliac spine proximally and the center of the upper edge of the tibial tubercle distally. Pretesting demonstrated that the author's reliability correlated for repeated measures at an r value of 0.876 (Appendix E).

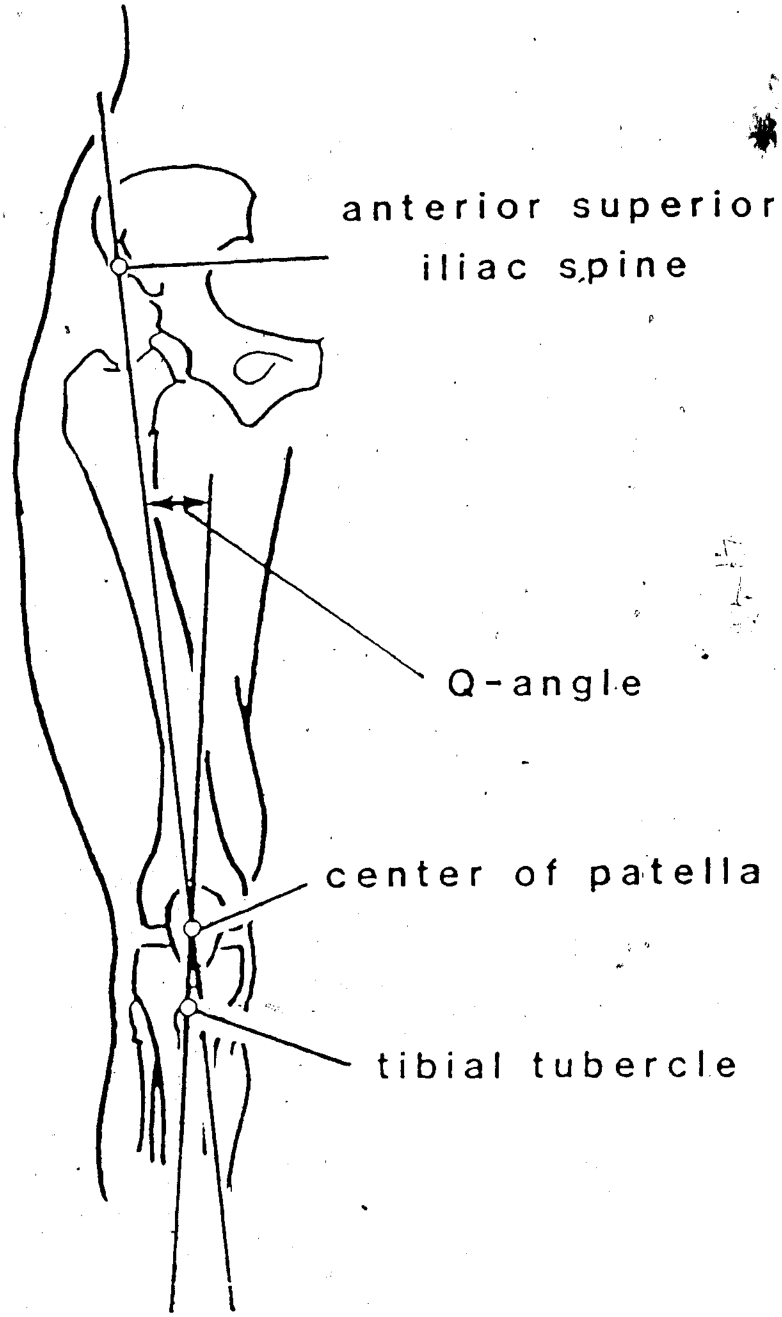


Figure 5. The Q-angle was measured with the patient lying relaxed in the anatomical position and the medial borders of the feet were held together.

12. **Crepitus** - This sign was tested in both sitting and lying to obtain a full range of motion (ROM).

Passive testing was performed with the examiner moving the relaxed leg through the ROM while cupping the palm of one hand lightly over the patella being tested.

Resisted testing was performed with the examiner providing maximal manual resistance that still permitted movement through the ROM.

1) None - No clicking, grating or grinding felt or heard by the examiner.
2) Mild - Creaking or clicking felt by the examiner.
3) Severe - Grinding and/or crunching felt and heard by the examiner.

13. **Grading of Chondromalacia Patellae** - This was graded according to the criteria described by Metcalf[17]:

a. Grade 0 - No softening, fibrillation or other evidence of chondromalacia; normal articular surface.
b. Grade 1 - Softening and appearance of "blistering". The center of the patella felt spongy when probed.
c. Grade 2 - Fissuring and minor fibrillation not extending down to subchondral bone when probed.
d. Grade 3 - Deep fissuring, fragmentation and fibrillation, with clefts extending down to

subchondral bone when probed, covering less than 50 percent of the articular surface of the patella.

e. Grade 4 - Extensive fibrillation of the articular cartilage going down to subchondral bone over more than 50 percent of the articular surface, often with areas worn down to and exposing subchondral bone.

F. Delimitations

The investigation was delimited as follows:

1. All subjects were patients of one orthopaedic surgeon at the University of Alberta Hospital.
2. The subjects were all between fifteen and thirty years of age.
3. All subjects required knee surgery for either retropatellar pain, meniscal pathology, or ligamentous pathology.
4. Patients excluded from the study fit one or more of the following classifications:
   a. chondromalacia patellae secondary to recurrent dislocation of the patella;
   b. osteoarthritic changes on roentgenogram;
   c. pathological synovial plicae demonstrated during surgery;
   d. inability to passively extend knee to zero degrees;
   e. more than a mild effusion in control group patients;
   f. previous knee surgery in the control group.

G. Limitations

The limitations imposed on the study were as follows:

1. The grading of chondromalacic changes on the retropatellar surface was dependent on the extent to which the surgeon adhered to the grading classification designated for the study.
2. The accuracy of the clinical examination was dependent on the extent to which the investigator adhered to the definitions for each symptom and sign analysed in the study.
3. The accuracy of the symptom classification was dependent on the extent to which each subject honestly and reliably answered the questions pertaining to his or her symptoms.
4. The blood pressure values were dependent on the accuracy and reliability of the investigator measuring systolic blood pressure by auscultation technique. Pretesting demonstrated that the investigator's reliability correlated with a designated expert at an r value of 0.98 (Appendix E).
5. The intraosseous venous pressure values were dependent on the accuracy and reliability of the technique and apparatus used for measurement.

Chapter II

LITERATURE REVIEW

A. Introduction

The term chondromalacia patellae is presently used to refer to a clinical syndrome of anterior knee pain, the causes of which are numerous and varied. The true definition of chondromalacia patellae is softening, fibrillation, fissuring and erosion of the articular cartilage of the patella[18]. Although the symptom complex is commonly thought to be caused by the cartilage degeneration, this is not always the case. During surgery for other knee pathology on patients with no symptoms of retropatellar or peripatellar pain, cartilaginous fibrillation is a frequent incidental finding[19]. The opposite has also occurred, whereby surgery has been performed for the chondromalacia patellae pain syndrome and no cartilaginous lesion was found[20].

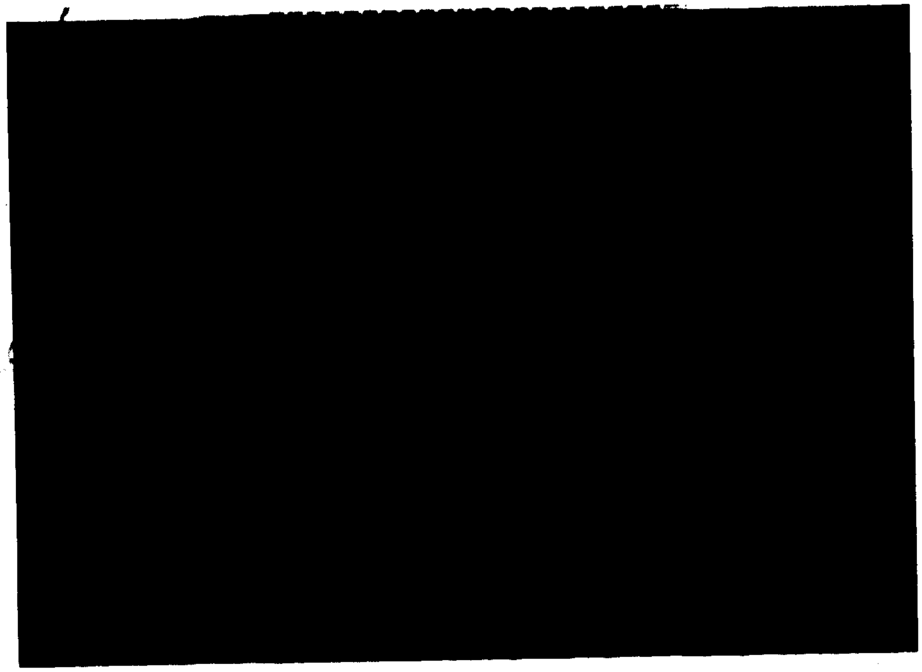
The symptomatology of the chondromalacia pain syndrome[21] includes diffuse aching pain felt in the retro-patellar area, that is exacerbated by ascending and particularly descending stairs, or sitting with the knee flexed[20]. The knee may also give the feeling of locking or giving-way[20]. Objective findings may include quadriceps atrophy[22], mild effusion[20,22], decreased pain-free range of flexion[23], crepitus[21], pain on patellar compression[21], tenderness on palpation of the articular surface[21], and a positive Clarke's Sign[24].

Many conditions may cause symptoms similar to true chondromalacia patellae. These conditions include malalignment syndromes[25], reflex sympathetic dystrophy[7], trabecular microfracture due to overload[26], venous congestion of the patella[8], symptomatic synovial plicae[27], and medial meniscus lesions[28].

B. Location of Cartilage Lesions

The location of the cartilage damage in chondromalacia patellae has been investigated by many authors[7,19,20,29]. Goodfellow and Hungerford[20] suggest that there are two types of lesions that occur in the articular cartilage of the patella. The two types of lesion that these authors describe are firstly an age dependent lesion that commences with surface flaking and secondly a lesion commencing in the deeper (basal) layers of cartilage.

The surface flaking in the first type of lesion may progress to involve deeper layers of the cartilage and eventually expose subchondral bone. In other joints of the body, surface degeneration has been reported to first occur in a location of habitual non-contact. In the patello-femoral joint, this type of lesion is frequently limited to the odd facet of the patella (Figure 6). In contact studies[29] of this joint, it has been demonstrated that the odd facet does not contact the femur until beyond ninety degrees of flexion, which is an uncommon range of motion in our society.



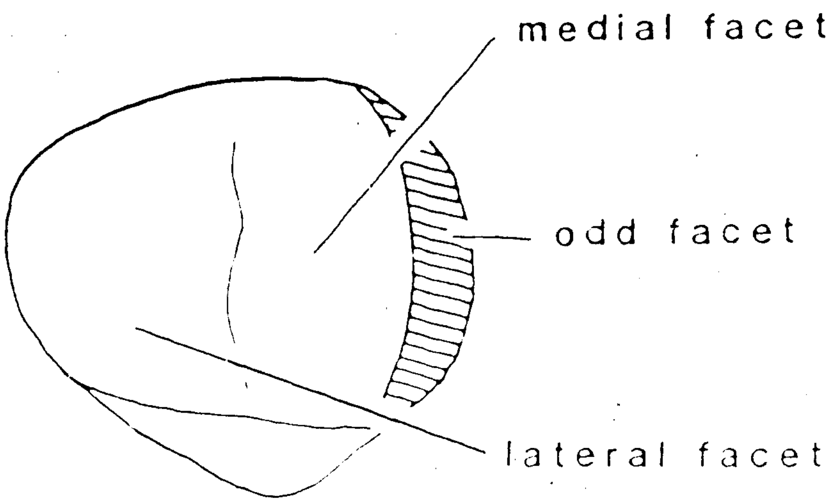


Figure 6. Patellar articular surface. a) Photograph of the retropatellar surface. b) Diagrammatic highlighting of facets in a).

Minns et al.[30] conducted stress analyses of the patella taking into consideration a number of alignment and anatomical variations. These authors believe the surface lesion described by Goodfellow and Hungerford[20] to be a result of tensile fatigue caused by the constant stresses imposed on the surface layer of the cartilage in the area of the odd and medial facets. In their stress analysis, a combination of quadriceps and retinacular forces produced a resultant bending moment on the patella that became larger as the static Q-angle was increased. In the situation where the medial and odd facets were small, the calculated values of tensile stress in the region of the odd facet approached values demonstrated[12] to be the tensile fatigue limits of collagen in cartilage. Minns et al.[30] outlined the hypothetical subject who would bring these tensile stresses extremely close to the failure range as an individual who exhibited the combination of a large Q-angle, a patella with a small, convex medial facet and was also overweight. In this type of individual, an increased level of activity would probably put these stresses into the critical range.

Surface degeneration does not often produce symptoms until it progresses to expose subchondral bone, a situation that develops more frequently after the fourth decade than in the younger population[31].

Outerbridge[32] believed that a chondro-osseous ridge on the superior edge of the medial femoral trochlea produced a similar lesion on the odd facet as that previously described[20]. His assumption was based on a study of 240 patients undergoing menisectomy and 35 necropsy specimens. Outerbridge reported the mean height of this ridge as 0.33 centimeters in cases with severe chondromalacia and 0.22 centimeters in those cases with mild chondromalacia. He concluded that these findings suggested "a direct relationship between the rim height and the severity of the chondromalacia". However, Emery and Meachim[33] were not able to support this hypothesis in their autopsy study of 136 patellofemoral articulations. These authors[33] did not find a correlation between degeneration of the odd facet and the presence of the ridge Outerbridge describes.

The second type of lesion that Goodfellow and Hungerford[20] described is called basal degeneration. During the initial stages of degeneration, the middle and deep layers of the cartilage are damaged but the surface remains intact, resulting in a softened area of cartilage with a normal glistening surface. Further progression may lead to blister formation followed by eruption and subsequent fasciculation.

The collagen fiber orientation of the middle and deep zones, which is nearly perpendicular to the surface, normally absorbs and distributes the forces transmitted to the subchondral bone[34] (Figure 7). Since the articular cartilage has no innervation, destruction of these layers in itself does not cause pain. However, this zonal destruction permits greater forces to reach the richly innervated

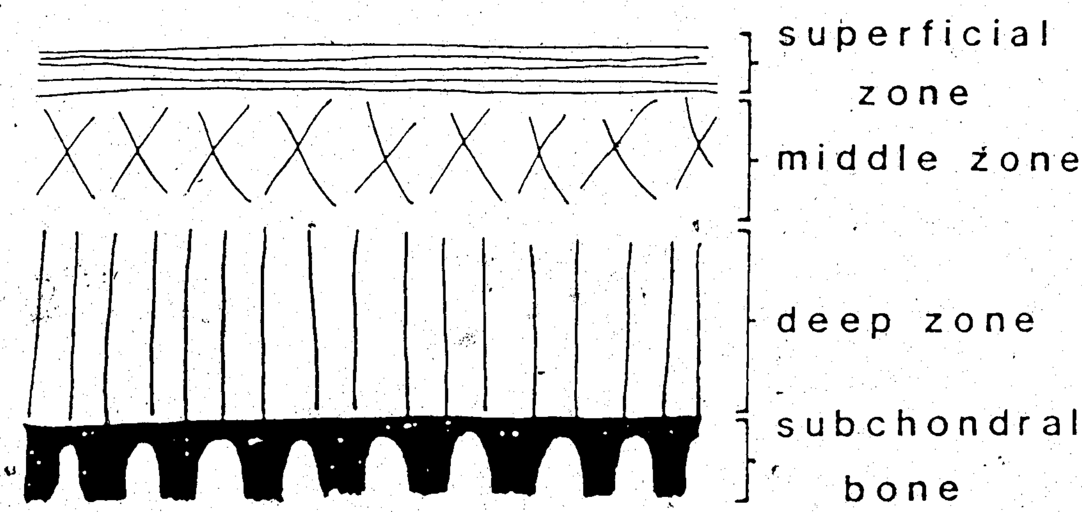


Figure 7. Diagrammatic representation of the orientation of collagen fibers in the various layers of articular cartilage.

subchondral bone, thereby producing pain with joint loading. In the first type of lesion (open, age-related), the middle and deep zones remain intact until late in the progression. Hence, the cartilage retains much of its energy absorbing ability and pain may not be present until advanced stages. However, with the basal degeneration lesion, these zones are disrupted in the initial stages and pain is a factor early in the process[20].

The two common areas of occurrence of the basal degeneration lesion on the patella are the ridge between the medial and odd facets as well as the ridge separating the medial and lateral facets[20]. Minns et al.[30] examined the types of forces to which these areas are exposed. The ridge between the medial and odd facets is subjected to both high compressive loads and large shearing forces as it moves over the junction between the femoral trochlea and the medial femoral condyle. The combination of these forces is hypothesized to cause the middle and deep collagen fibers to fail as a result of the shear fatigue phenomenon. Shearing forces are imparted to the middle and deep layers as a consequence of the more perpendicular orientation of these fibers to the surface.

As the ridge between the odd and medial facets rarely articulates with the femur short of ninety degrees[29], it is thought to be more susceptible fatigue as a result of poor nutrition. The lack of nutrition to the deeper layers probably results from the combination of several factors. As the compression of this ridge by articulation with the femur is infrequent, the amount of fluid interchange occurring between the synovial fluid and the cartilage in this area is mostly limited to passive diffusion[34]. Also, as the articular cartilage of the patella is the thickest in the body[35,36], it is doubtful that diffusion alone is sufficient for the metabolic requirements of the deeper layers in this area.

C. Lesion Progression

Grade four chondromalacia patellae, as described by Metcalf[17] is :

> extensive fibrillation of the articular cartilage going down to subchondral bone over more than fifty percent of the articular surface, often with areas worn down to and exposing subchondral bone.

It has been suggested that the state of the cancellous bone deep to the affected cartilage determines whether or not a particular lesion progresses to the extent of subchondral bone exposure[37]. Townsend et al.[11] in their studies of the trabecular structure and orientation in the patella, have tested the stiffness of the underlying bone. In areas such as the central-medial facet, they found the trabecular bone to be disorganized and osteopenic. The central-medial facet of Townsend et al.[11] corresponds with the contact area on the medial facet that Goodfellow et al.[20] describe as articulating with the femur at forty-five degrees of flexion. Townsend et al.[11] calculated the strain at which trabecular buckling occurs and compared this value to data produced by Reilly and Martens[36] concerning patello-femoral reaction forces during various activities. The values for strain during stair climbing[36] surpass the limits for trabecular buckling according to the results of Townsend et al.[11]. They proposed that the constant overload occurring in the central-medial region may prevent bony remodelling from ever managing to completely repair the damage. As a result, the bone deep to this region remains osteopenic and therefore more compliant. With increased compliance of the subchondral bone, less reaction force is exerted on the cartilage and degeneration does not progress[11].

Emery and Meachim[33] believed that cartilage deterioration commencing on the lateral facet eventually spread to include the central ridge and the medial facet, but changes beginning on the central-medial facet did not usually progress. This typical progression corresponds with the work of Townsend et al.[11] in which the lesion began over the relatively compliant medial facet and did not progress. Townsend et al.[11] also demonstrated greater stiffness of the lateral facet as compared to the medial facet in the normal patella, perhaps predisposing the lateral facet to a progressive lesion. Pedley and Meachim[37] also found the stiffness of the lateral facet to be greater when cartilage degeneration occurred on that facet.

Radin et al.[38] proposed that the non-progressing lesion on the medial facet be called chondromalacia patellae, whereas the lesion on the lateral facet, that almost invariably progresses, be referred to as patellar osteoarthrosis.

D. Blood Supply and Venous Drainage

Bjorkstrom and Goldie[7] examined patellae from six amputated limbs and fifteen autopsy specimens aged 17 - 70 (mean = 34) and found that the arteries in the subchondral bone were wider and more tortuous deep to areas of degenerative cartilage. The increased caliber of these vessels were thought to result from the back pressure produced by impaired venous drainage[4]. However, the reason for the impaired venous drainage, if in fact that is what it was, has not been determined.

Radin[2] suggested that microfractures of the trabeculae occur in the subchondral bone when the joint is overloaded which may be caused either by repetitive loading resulting in fatigue fracture or by a single stress incident. Furthermore, he suggested that the healing of these microfractures caused blockage of the normal routes of venous drainage. It has been demonstrated in animal studies[10] that chronic venous congestion can produce an increase in the trabeculation of bone. Hence, once the initial blockage occurs then a self-sustaining cycle may be developed.

Lemperg[4], Lynch[5], and Arnoldi[39] have all suggested that venous engorgement and intraosseous hypertension play a role in the etiology of pain in osteoarthritis in weightbearing joints. Arnoldi[39] has also found intraosseous hypertension to be the cause of pain in some patients with no clinical or radiological signs of osteoarthritis. The description of this pain is given by Arnoldi[39] as :

> constant aching pain...independent of joint movement or loading...

Helal[40] classified three types of pain in primary osteoarthritis of the knee : muscular, capsular, and venous. He described the venous pain as :

> A dull aching or throbbing pain felt diffusely about the knee, usually worse towards the end of the day and persisting for a while after retiring to bed.

He stated that reproduction of this venous pain could be achieved by artificially increasing the intraosseous venous pressure of the bones adjacent to the affected joint by injecting heparinized saline into the bones.

Waisbrod and Treiman[8] demonstrated impaired venous drainage from the patella in both patellae with osteoarthritis and chondromalacic patellae. Using phlebography, these authors could detect markedly slower drainage times in the above two conditions as compared to the normal patellae tested, but they could not distinguish between the two conditions.

Intraosseous pressure of the patella in chondromalacia patellae has been measured in one study reported in the literature. Bjorkstrom et al.[6] measured intraosseous pressure of the patella in twenty-nine subjects under general anesthesia. The age range for the subjects was 18 - 38 with a mean of 27 years. Thirteen subjects had chondromalacia patellae graded according to Collins[41] (six of these also had medial meniscal lesions), three subjects had osteoarthritis (grade three chondromalacia patellae in subjects forty years of age and over) and thirteen subjects undergoing menisectomy acted as controls. However, three of the control patients were found to have grade one chondromalacia patellae and one had neither meniscal or patellar involvement. The chondromalacia patellae group were scheduled for surgery if the symptoms had persisted or became worse during a four month period or longer, or if the patients had unsuccessfully completed conservative treatment consisting of : 1) avoidance of aggravating activities, 2) isometric quadriceps training, and 3) a two to four week trial of anti-inflammatory medication. The grading of chondromalacia patellae was done during arthrotomy.

Measurement of intraosseous pressure was made through a small incision on the medial margin of the patella. The investigators[6] drilled a two millimeter diameter Gidlund biopsy needle 15-20 millimeters into the bone. The biopsy needle was then flushed with 0.9 percent saline solution. Following this, the needle was connected via a saline-filled polyethylene catheter to a capacitance transducer and the pressure was recorded on a Mingograph (Elema). In all but one subject, a pulse wave was registered indicating a satisfactory connection. The pressure could still be measured in the one patient in which the pulse wave was disturbed by technical error. No complications occurred during the pressure measurements or post-operatively.

Presentation of results by Bjorkstrom et al.[6] included all raw data pressure measurements, sex, age and grade of chondromalacia patellae along with group means and ranges for pressure measurements. However, no statistical analyses were performed by the authors[6]. Using the raw data presented, a Student's t-test was calculated by the author of the present study comparing the values for the chondromalacia patella group with the control group. The result was not significant at the 0.05 level of probability for a one-tailed test, however it was significant at the 0.10 level of probability.

A one-way analysis of variance was calculated to analyse the control group (designated grade 0) with the grades of chondromalacia patellae (1-3)[41]. The F value was significant at the 0.01 level. However, only the Scheffé Multiple Comparison Test between groups 0 (control) and 3 was significant at the 0.05 level of significance or better ($p < .01$). Group means, ranges and statistical values are presented in Appendix A.

Ficat and Hungerford[7] estimate the intraosseous pressure of the normal patella to be 10-15 mm Hg. Bjorkstrom et al.[6] found the mean of their comparison group (normal estimate) to be 15 mm Hg once they had withdrawn four contaminating subjects from their group thereby reducing their n to nine. Ficat and Hungerford[7] do not report pressures in chondromalacia patellae, but mention that in a condition they call "reflex sympathetic dystrophy" of the knee, intraosseous pressures of the affected patellae were in the range of 30-50 mm Hg.

It has been suggested that the immediate relief of pain reported following excision of affected cartilage and drilling of the subchondral bone for chondromalacia patellae[42] may actually be due to the fenestration, and resultant decongestion[5,43] of the patella, rather than the excision of cartilage.

E. Alignment

Many authors have described anatomical variations that are thought to predispose an individual to developing chondromalacia patellae[7,44,45,46]. All of these variations interfere in some way with the tracking of the patella in the trochlear groove of the femur. For the purpose of describing these factors they have been separated into the following classifications : skeletal, non-contractile soft tissue, and muscular.

Skeletal

Any skeletal variant altering the direction of pull of the quadriceps muscles, the attachment of the ligamentum patellae or the pulley system of the patella over the femoral condyles, will change the forces acting upon the patella.

The width of the pelvis, and therefore the position of the anterior inferior iliac spine, alters the relative origin of the rectus femoris muscle and the orientation of the femur as it angles from the hip to the knee joint[47]. It is this angle of the femur that obviously determines the origin of pull of the vasti muscles on the patella in the coronal plane (Figure 8). Femoral anteversion and femoral rotation, on the other hand, change the orientation of the femoral condyles about a quasi-vertical axis thereby partially determining the orientation of the patella on this same axis[46]. The size of the femoral condyles has been implicated by some authors as contributing to tracking problems[48].

The location of the tibial tubercle also determines the angle of the ligamentum patellae. The more laterally the tubercle is placed, the greater the angle between the pull of the quadriceps on the patella and the attachment of the patella to the tibia via the ligamentum patellae. Hence, the resultant force tending to pull the patella laterally is greater[49].

The angle of the femur with the tibia also affects the angulation occurring about the patella[46]. Genu valgum increases this angle and genu varum affords a straighter line of pull.

Tibial torsion alters the orientation of the ankle joint with the knee and hip joints[50]. The orientation of the ankle mortise determines the angle in which the talus and

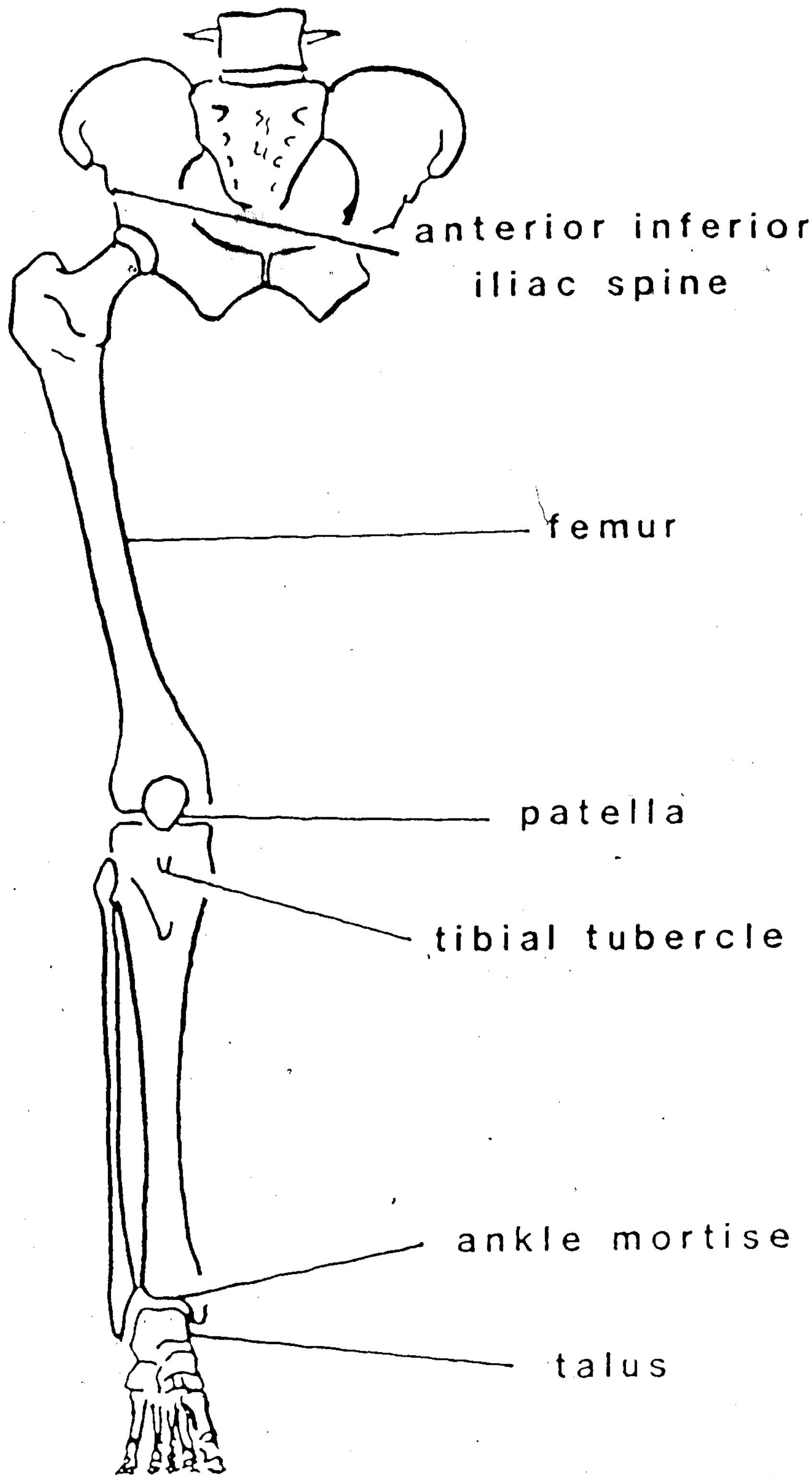


Figure 8. Skeletal anatomy of the lower extremity.

foot are directed[51]. The direction of foot progression during gait has been measured by Staheli et al.[51] as an overall measure of lower-extremity rotation. Some compensation for excessive rotation of the leg may occur at the subtalar joint to reduce the functional angle of pull of the quadriceps mechanism[52]. Pronation (or eversion) will increase medial rotation of the leg and supination (or inversion) will position the leg into more lateral rotation[52]. James[52] categorizes one group prone to patello-femoral problems as having "miserable malalignment". This group is typified by a combination of the following rotational deformities : squinting patellae (indicative of femoral anteversion or femoral torsion), apparent genu varum, often associated with recurvatum, patella alta, a prominent fat pad, increased quadriceps angle with external tibial rotation, real tibial varum and compensatory pronation[52].

The clinical measurement to evaluate the angle of pull of the quadriceps mechanism is known as the quadriceps angle or the Q-angle (Figure 5). The middle of the patella is the axis, with the anterior superior iliac spine and the tibial tubercle acting as the proximal and distal bony landmarks from which the angle is determined. A line connecting the anterior superior iliac spine and the middle of the patella is compared with a line from the tibial tubercle through the same central point on the patella. The acute angle between these two lines is the Q-angle[53]. Unfortunately, the proper position of the patient for the measurement of the Q-angle is not well agreed upon in the literature. One author had the patient stand with the legs fully extended, the medial borders of the feet parallel and the buttocks square[54]. Other authors positioned the patient in lying with the legs together and relaxed[44,55,56]. Larson[53] mentioned that an additional control for rotation in this position was to hold the feet straight up. Henry et al.[57] said the knee should be flexed to a particular angle. Insall et al.[25] gave normative data but did not specify the position that was used. With such discrepency between testing positions, obviously the normative data reported by these various authors is difficult to compare.

The amount of rotation in the femur and tibia has been evaluated in many different ways in the literature[46,49,50]. However, the position of the patella has not been objectively measured clinically in relation to the coronal plane. Perhaps the reason for the lack of an objective quantitative clinical measurement is that there are many factors influencing the position of the patella, only one of them being skeletal.

Non-contractile Soft Tissues

The static stabilizers of the patella consist of the lateral retinaculum, composed of expansions from the ilio-tibial band, the lateral patello-femoral and menisco-patellar ligaments; the medial retinaculum formed by the medial patello-femoral and menisco-patellar ligaments; and the ligamentum patellae[7] (Figure 9).

The relative tautness of the medial and lateral retinacula[1], and the length of the ligamentum patellae as compared to the length of the patella[49,58], are factors determining the angle at which the patella sits and where it articulates with the femoral trochlea.

If the medial retinaculum is loose, or becomes stretched, the patella is permitted to drift laterally during flexion and extension of the knee[57]. In more pronounced cases, this lateral drifting may result in lateral subluxation or dislocation of the patella[57]. In less severe situations, the contact pressures on the facets of the patella are altered from the norm[49].

With any prolonged lateral drifting, the lateral retinaculum becomes adaptively shortened causing increased lateral tethering and tilting of the patella, and thereby producing greater lateral compartment contact pressures[7].

The length of the ligamentum patella relative to the length of the patella has been implicated in the possible etiology of chondromalacia patellae[1,49] (Figure 10). The average ratio of the length of the patella to that of the ligamentum patella is 1.02 (SD : 0.13)[59]. In chondromalacia patellae, this value is smaller than in normals (0.86 $p < .05$)[60]. Huberti et al.[49] have demonstrated the importance of the articulation of the quadriceps tendon with the femoral trochlea in decreasing the contact pressures of the

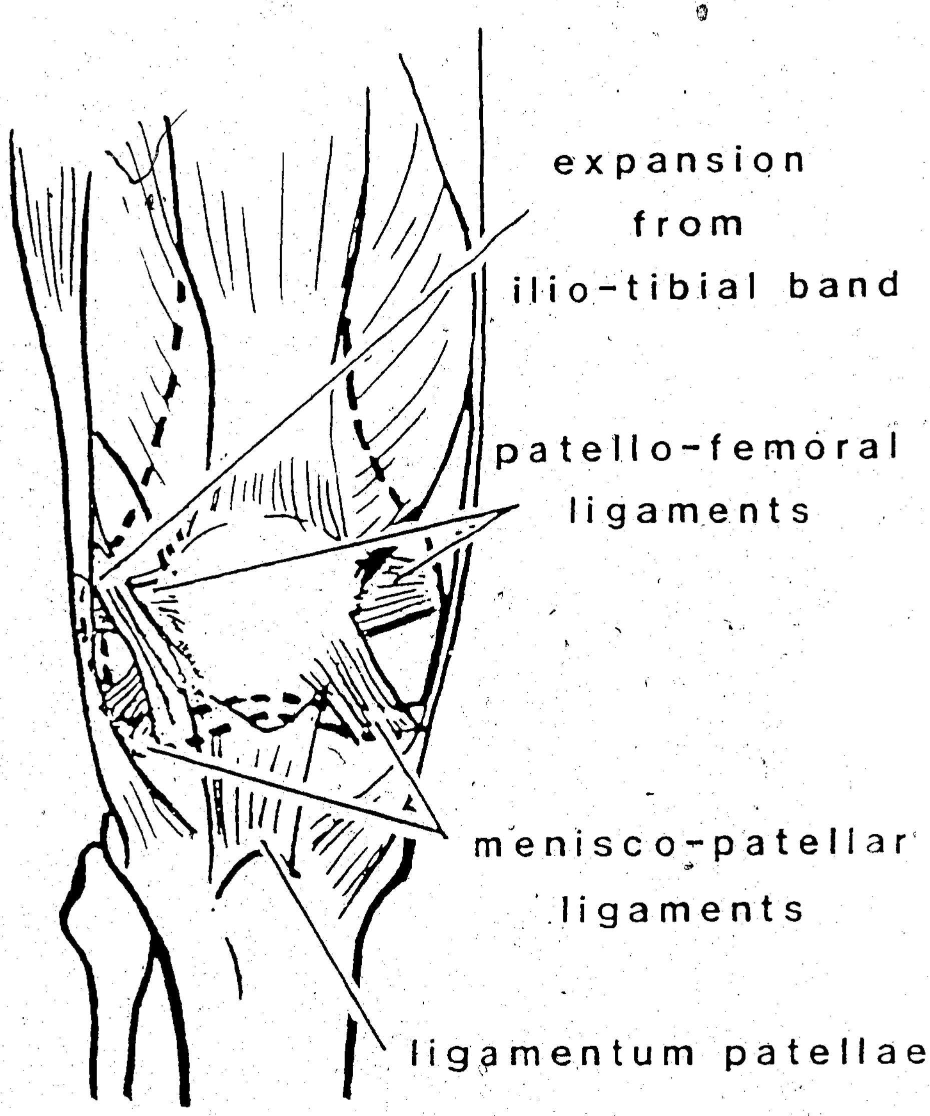


Figure 9. Diagram of the static stabilizers and muscular attachments to the patella.

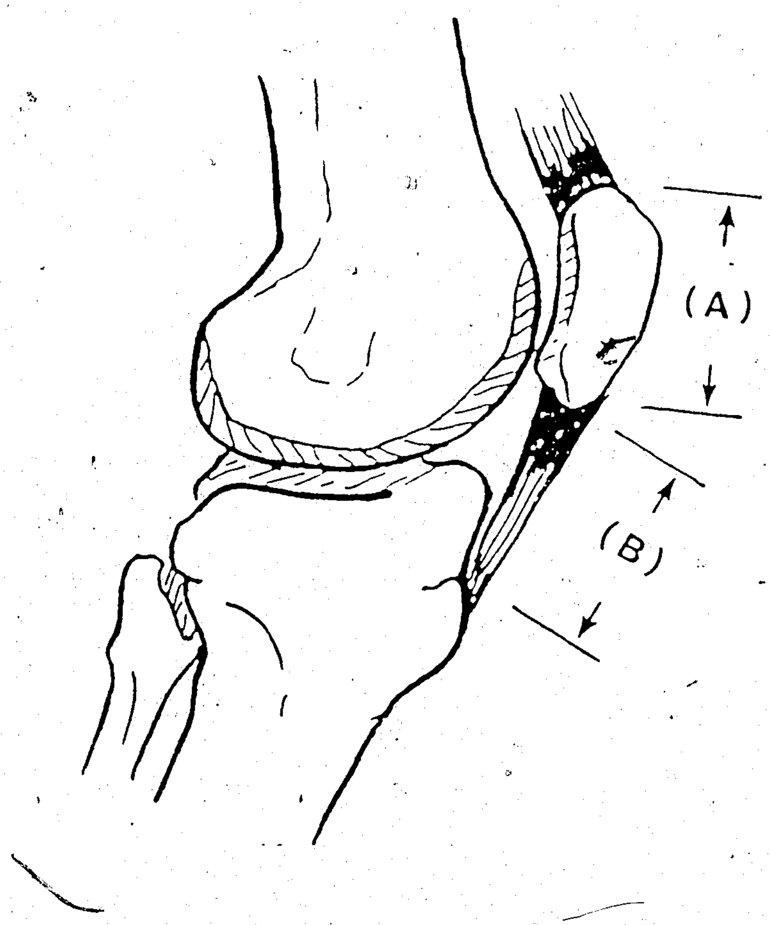


Figure 10. Diagrammatic representation of the ratio of the length of the patella (A) to that of the ligamentum patella (B). Normal = 1.02/1.00

patello-femoral joint at angles of flexion in the region of 120° degrees and greater. It has been demonstrated in cases with excessively long patellar tendons that the patello-femoral contact forces are greater at high angles of flexion[41]. The enlarged surface contact area provided by quadriceps tendon articulation in the normal population occurs to a much lesser extent in the group with longer ligamentum patellae, because the patella is riding higher in the trochlea.

Genu recurvatum is another factor mentioned in the literature as part of the etiology of chondromalacia patellae[43,44,45,61]. Generalized ligamentous laxity is usually associated with the ability to hyperextend ones knees unless trauma has produced the hypermobility. The existence of an actual cause-effect relationship between genu recurvatum and chondromalacia patellae has yet to be established, although it is included in James' description of miserable malalignment[52].

Muscular

The resultant force of the quadriceps muscles during knee extension and controlled knee flexion is one of many factors which guides the patella through the femoral trochlea. The quadriceps muscle group along with skeletal alignment, the shape of the articulating surfaces, and the tension of the static stabilizing structures determine the tracking of the patella and the contact pressures of the patello-femoral articulation[62].

Excessive lateral tracking may occur in cases of vastus medialis dysplasia where the insertion of the oblique fibers of the medialis on the patella are more proximal than normal[44,56,57]. Another situation permitting lateral tracking occurs when the balance of forces between the vastus medialis and the other three quadriceps muscles is disrupted, such as when the vastus medialis is reflexly inhibited or atrophies[43,61,63] due to pain or pathology.

F. Pain on Compression

Manually compressing the patella against the femur with the quadriceps relaxed is a commonly performed clinical test on patients presenting with patello-femoral pain[18,20,35,64]. However, this test is often described with the knee in zero degrees of flexion[22,44]. In this position, the patella is not articulating with the femoral trochlea and compression of the patella only exerts pressure on the supratrochlear fat pad and soft tissues composing the suprapatellar pouch. These structures are highly innervated by pain fibers, hence when pinched, give false positive test results. Some authors[55,65] suggest placing the knee in a small amount of flexion to achieve patello-femoral trochlear contact, and patellar facet compression. The position recommended varies from ten degrees to ninety degrees[55,65].

Another variation to the retropatellar compression test is the dynamic retropatellar compression test[66], also known as Clarke's Sign[7]. The dynamic test is described in Chapter One under Definition of Terms. In a review article by Hoke et al.[15], it was demonstrated that the positioning of the knee for this test varied considerably between authors. Zero degrees of flexion appears to be the original position described[67,68], however authors have modified the angle of flexion for the test from "slight flexion" to forty-five degrees[24,64,69].

G. Crepitus

Crepitus, with regard to joint movement, is defined in the literature as a sensation of squeaking, grating or crunching on articulation or audible clicking[35,44,46,57], grating[70], crunching or cracking during joint movement[19,20]. Examination for crepitus of the patello-femoral joint includes cupping of the examiner's hand over the patella with the examiner resisting active knee extension[46,71].

Some authors believe that crepitus is not of much diagnostic significance for chondromalacia patellae[20,57], however, they do not give any reason for their statements.

H. Effusion

A significant effusion is considered by some authors to be a rare occurrence in patients with chondromalacia patellae as the chief pathology[18,20,22,25,55]. However, in open lesions of the articular cartilage, irritating substances are released into the synovial fluid that may produce a minor effusion[20].

A recent animal study[72] has demonstrated increased intraosseous pressures in the patella when effusions were artificially produced in the knee joints of dogs. It appears from this work that a moderate effusion, or greater, was necessary to cause an increase in intraosseous pressure[72].

Chapter III

METHODS AND PROCEDURES

A. Subjects

A prospective study was conducted using patients of one orthopaedic surgeon at The University of Alberta Hospital during 1983 and 1984.

All subjects were between fifteen and thirty years of age. Inclusion criteria were :

a. Retro-patellar pain severe enough to require surgery (defined as those reporting a history of pain longer than six months, an unsuccessful trial of anti-inflammatory medication, isometric quadriceps exercises, and avoidance of aggravating activities);

b. Meniscal pathology requiring surgery;

c. Ligamentous pathology requiring surgery.

Patients were excluded from the study if they were clinically diagnosed as having chondromalacia patellae secondary to recurrent dislocation, if they had osteoarthritic changes on roentgenogram, or if they were found at the time of surgery, to have pathological synovial plicae. The etiology of the chondromalacic changes was not in question in patients who experienced recurrent patellar dislocation. Osteoarthritic changes on roentgenogram were defined as osteophyte formation producing lipping on any knee joint surface. This study was examining retro-patellar pain with chondromalacic changes, not advanced osteoarthritis. Patients with pathological synovial plicae may exhibit a similar clinical picture as patients with chondromalacic changes of different etiology. However, the etiology of the chondromalacia patellae in these instances was probably produced by the friction of the plica on the joint surface[27].

Patients in whom a fully extended position of the knee to neutral (zero degrees) could not be achieved clinically were also excluded from the study because the intraosseous venous pressure measurement was performed with the knee in neutral[4]. Any patient not in the chondromalacia patellae group demonstrating more than a very mild effusion was excluded on the basis that a recent study[72] on dog knees has shown an increase in intraosseous venous pressure with artificially produced moderate knee effusions.

B. Apparatus

Assessment Form

The assessment form used to evaluate pre-surgery signs and symptoms is in Appendix B.

Grading of Chondromalacia Patellae

The state of cartilage degeneration was graded by the surgeon through the arthroscope or during arthrotomy according to the criteria described by Metcalf[17] :

Grade 0 - No softening, fibrillation or other evidence of chondromalacia; normal articular surface.

Grade 1 - Softening and appearance of "blistering". The center of the patella feels spongy when probed.

Grade 2 - Fissuring and minor fibrillation not extending down to subchondral bone when probed.

Grade 3 - Deep fissuring, fragmentation and fibrillation, with clefts extending down to subchondral bone when probed, covering less than 50 percent of the articular surface of the patella.

Grade 4 - Extensive fibrillation of the articular cartilage going down to subchondral bone over more than 50 percent of the articular surface, often with areas worn down to and exposing subchondral bone.

Systemic Blood Pressure

The systemic blood pressure was measured by the author using the technique described by the American Heart Association[73]. The pressure was taken with the patient lying supine on the operating table and the shoulder at 90 degrees of abduction. A Sanborn † stethoscope and an aneroid sphygmomanometer ‡ were employed for the blood pressure measurements.

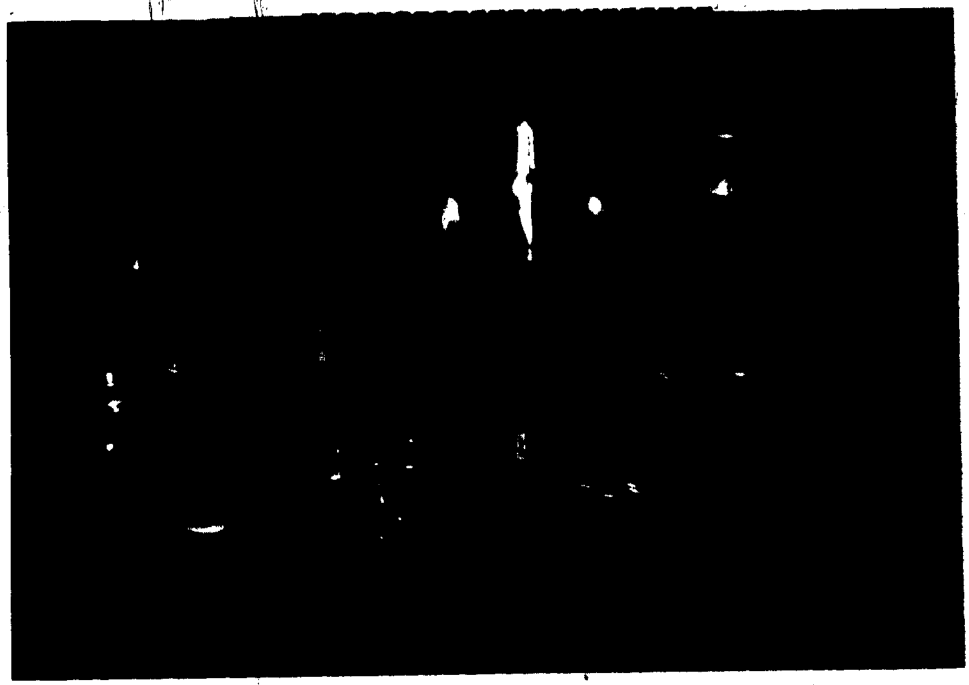
Intraosseous Venous Pressure

A 13 gauge hypodermic needle was coupled by a three-way stopcock with a Bentley Trantec Physiological Pressure Transducer đ via a 1.2 meter length of polyethylene tubing filled with 1.0 Normal saline (Figure 11). The transducer

----

† Rappaport Sprague, Hewlett Packard, Waltham, Massachusetts
‡ Ingram & Bell Inc.,Toronto
đ Bentley Trantec Inc., Irvine, California

COLOURED PICTURES
Images en couleur



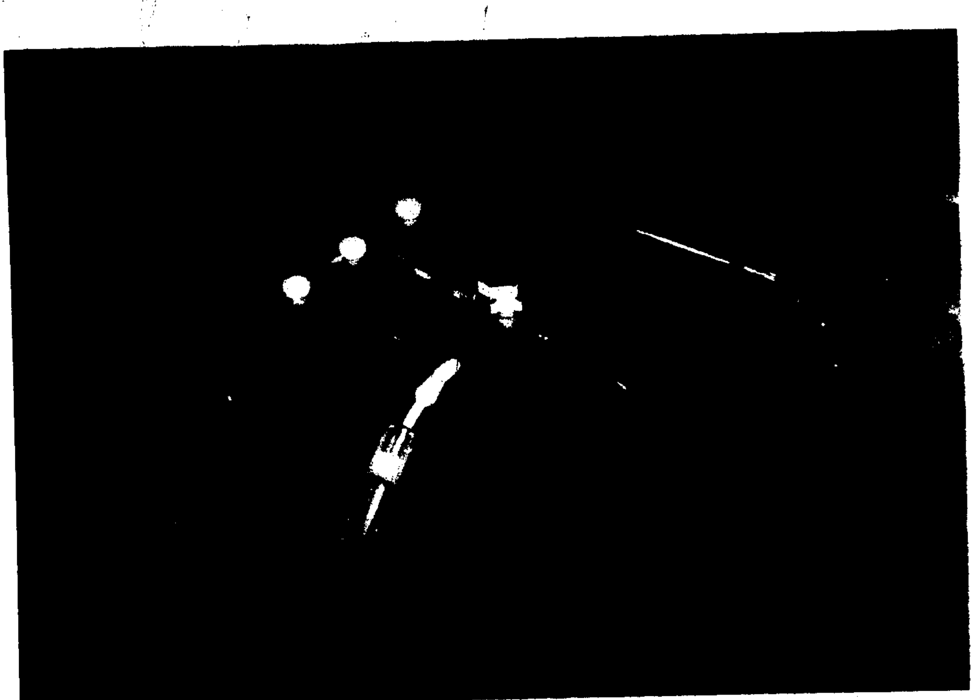


Figure 11. Apparatus for measuring intraosseous venous pressure.

was connected to a Vitatek 514 Monitor † that gave a digital readout of the intraosseous venous pressure.

C. Procedure

Following admission to The University of Alberta Hospital, the patients satisfying the selection criteria were approached concerning their voluntary participation in the study. In the cases where informed consent was obtained (see Appendices C and D for consent forms) the roentgenograms were examined to exclude any patients with gross osteoarthritic changes. Following the X-ray examination, the patients were subjected to a clinical assessment (see Appendix A).

At the time of surgery, after the leg was prepared and draped, a small skin incision, approximately two millimeters in length, was made lateral to the patella. A 1/16 inch drill bit was inserted into the patella to a depth of two centimeters. Following the detachment of the drill, a 13 gauge hypodermic needle was fitted down over the drill bit and eased into the surrounding bone. The drill bit was then removed and the lumen flushed with saline using an 18 gauge spinal needle and a 10 milliliter syringe. The needle and the polyethylene tubing were connected while maintaining a fluid to fluid interface. Care was taken to maintain the knee in zero degrees of flexion (Figure 12) and to ensure that the transducer was at the same level as the patella.

---

† Vitatek, Hillsboro, Oregon

COLOURED PICTURES
Images en couleur

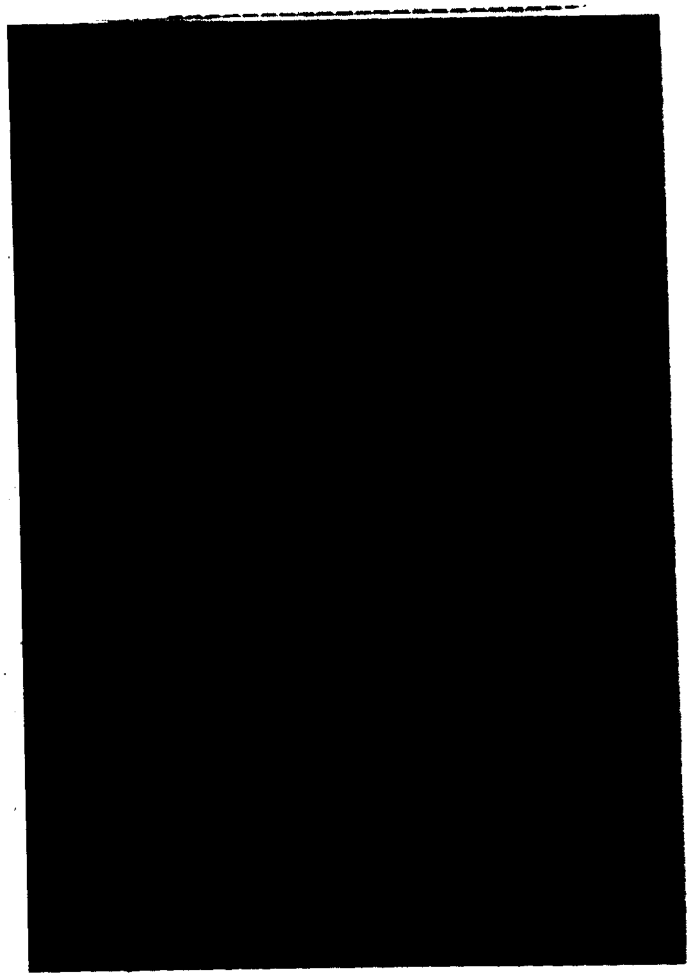


Figure 12. Measurement of intraosseous venous pressure.

The pressure was permitted to stabilize (approximately two minutes) prior to the pressure reading being recorded (Figure 13). Immediately following the removal of the needle from the patella, the needle was carefully flushed to check for bone particles or blood clots in the line. In the few cases in which this problem did occur, the data were discarded because a second attempt would not give reliable results due to the initial fenestration. The systemic blood pressure was measured concurrently with the reading of the intraosseous venous pressures[14].

Following the pressure measurements, the leg was stripped with a sterile Esmarch bandage and the tourniquet was inflated. The cartilage condition was then graded and the surgical procedure performed.

D. Data Presentation and Analysis

The data for each subject were collected on a Knee Assessment Form (Appendix B).

The .05 level of significance was adopted for all statistical tests.

The difference in intraosseous venous pressure (IOVP) between grades of cartilage degeneration was examined with a one-way analysis of variance (ANOVA) test[74]. This comparison was first done with the absolute patellar IOVP values, then as the percentage that the patellar IOVP was of the mean arterial blood pressure (IOVP/MAP x 100). Following these tests, a Scheffé Test for Multiple Comparison between groups

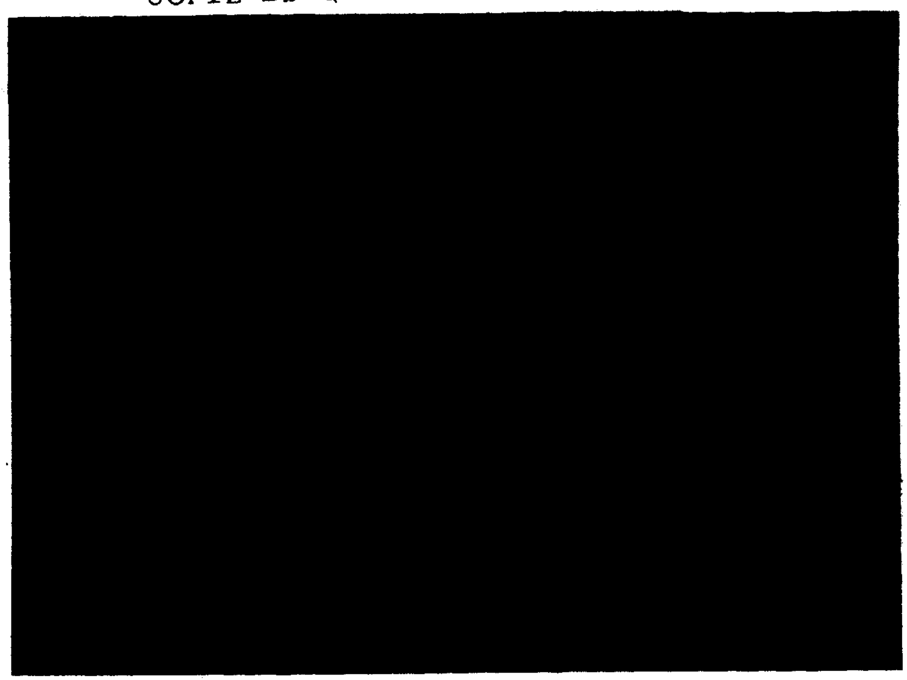


Figure 13. Intraosseous venous pressure wave and digital read out on the Vitatek 514 Monitor.

was employed regardless of whether a significant F was found[74].

One-tailed Student's t-tests[74] for independent samples were used to examine the difference in pressures between the groups with chondromalacic changes and the group without such changes. This test was performed first using the absolute IOVP, then using the IOVP/MAP x 100.

A one-tailed Student's t-test[74] for independent samples was employed to compare the difference in the IOVP and the IOVP/MAP x 100 between groups with and without the following symptoms and signs: rest pain, pain during stair climbing, pain when sitting with knees flexed, pain following activity, clicking, locking, catching, giving way, retropatellar pain on compression, and Clarke's Sign. The frequency of occurrence of these symptoms and signs was compared to the presence or absence of cartilage degeneration using a one-level Chi-Square test for nominal data.

A one-tailed Student's t-test for independent samples was utilised to compare the Q-angle between the chondromalacia patellae and the control groups. A one-way ANOVA test was used to examine the Q-angle as it pertained to the grade of chondromalacia patellae. The ANOVA was followed by a Scheffé Test for Multiple Comparison between groups regardless of whether a significant F was found.

To examine the relationship between Q-angle and IOVP, a Pearson Product Moment Correlation Coefficient was utilised.

For the clinical signs of alignment and crepitus, one-way ANOVA tests were performed to examine the difference in IOVP between severity levels. Two- and three-level Chi-Square tests were used to compare the severity of these signs to the existence of chondromalcia patellae.

Chapter IV

RESULTS

Forty-eight patients were assessed clinically followed by the measurement of the intraosseous venous pressure (IOVP) in their patellae. Twenty-four patients had chondromalacic changes of the patella graded during arthroscopy and twenty-four had no chondromalacic change. This latter group formed the comparison group. There were twelve males and twelve females in the chondromalacia patellae group, whereas the comparison group had fifteen males and nine females. Ages ranged from 15 to 28 in the chondromalacia patellae group with a mean of 21 years, whereas the age range in the comparison group was 16 to 30 with a mean of 22.5 years. Standard deviations were 4.5 for both groups. The purposes of the study were to determine whether patients with chondromalacic changes on their patellae had higher intraosseous venous pressures than those with normal patellae and whether certain signs and symptoms were indicative of either raised intraosseous pressures or chondromalacic change. The mean arterial pressure of each patient was measured concurrently with the intraosseous pressure to control for anesthetic variation[17]. All the statistical analyses were repeated with the intraosseous venous pressure measurement expressed as the percentage that the intraosseous venous pressure was of the mean arterial pressure (IOVP/MAP x 100).

The clinical symptoms chosen for analysis were rest pain, pain following activity, pain during stair climbing, pain while sitting with the knees flexed, clicking, locking, catching and giving way. The clinical signs analysed included pain on patellar compression, both at zero and twenty degrees of knee flexion, dynamic patellar compression (Clarke's Sign) at these two angles, measurement of the Q-angle, evaluation of crepitus on passive and resisted knee movement, and assessment of leg alignment including varus, valgus, recurvatum and rotation.

A. Intraosseous Venous Pressure

Intraosseous venous pressure (IOVP) of the patella demonstrated no significant difference between grades of cartilage degeneration using a one-way analysis of variance followed by a Scheffé Test for Multiple Comparison between groups. Table 1 shows the values obtained for these tests.

When the mean arterial pressure was included in the analysis (percentage that the intraosseous venous pressure was of the mean arterial pressure) there was no statistical significance (Table 2).

TABLE 1

Statistical Results for Comparison of the Intraosseous Venous Pressure(IOVP) Between Grades of Chondromalacia Patellae.

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP between	One-way ANOVA	2.59	1.43
GRADES:			
0 vs 1	Scheffe	10.36	0.1800
0 vs 2	Scheffe	10.36	2.3322
0 vs 3	Scheffe	10.36	1.4700
0 vs 4	Scheffe	10.36	0.6119
1 vs 2	Scheffe	10.36	2.6973
1 vs 3	Scheffe	10.36	0.7838
1 vs 4	Scheffe	10.36	0.8343
2 vs 3	Scheffe	10.36	4.0006
2 vs 4	Scheffe	10.36	0.0454
3 vs 4	Scheffe	10.36	1.7805
0 vs 1,2,3,4	Scheffe	10.36	0.1008
0,1 vs 2,3,4	Scheffe	10.36	0.4322
0,1,2 vs 3,4	Scheffe	10.36	0.2315
1 vs 2,3,4	Scheffe	10.36	0.5278
1,2 vs 3,4	Scheffe	10.36	0.0842

TABLE 2

Statistical Results for Comparison of the Percentage that IOVP was of the Mean Arterial Pressure (IOVP/MAP x 100) Between Grades of Chondromalacia Patellae.

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP/MAP x100	One-Way ANOVA	2.59	1.21
between GRADES:			
0 vs 1	Scheffe	10.36	0.9958
0 vs 2	Scheffe	10.36	0.8204
0 vs 3	Scheffe	10.36	2.8047
0 vs 4	Scheffe	10.36	0.4616
1 vs 2	Scheffe	10.36	2.5669
1 vs 3	Scheffe	10.36	0.9752
1 vs 4	Scheffe	10.36	1.0389
2 vs 3	Scheffe	10.36	4.3097
2 vs 4	Scheffe	10.36	0.1129
3 vs 4	Scheffe	10.36	2.2538
0 vs 1,2,3,4	Scheffe	10.36	0.0612
0,1 vs 2,3,4	Scheffe	10.36	0.2019
0,1,2 vs 3,4	Scheffe	10.36	0.0663
1 vs 2,3,4	Scheffe	10.36	0.5525
1,2 vs 3,4	Scheffe	10.36	0.0578

B. Symptoms

Pain During Stair Climbing

Pain experienced during ascending or descending stairs was the only symptom to demonstrate statistical significance at the .05 level when compared to the presence of cartilage degeneration (PFC) by Chi-square analysis (Table 3). However, the intraosseous venous pressure (IOVP) and the percentage that IOVP was of the mean arterial pressure did not display any statistically significant difference between groups who felt pain during stair climbing and those subjects who did not experience pain (Table 4).

None of the other symptoms analysed demonstrated statistical significance with regard to the presence of degenerative cartilage change (PFC), the intraosseous venous pressure (IOVP), or the percentage that the intraosseous venous pressure was of the mean arterial pressure (IOVP/MAP x 100). These results are displayed in Tables 5 through 12.

TABLE 3

Chi-Square Contingency Table for Pain During Stair Climbing versus a) Subjects with Cartilage Degeneration, and b) Subjects without Cartilage Degeneration.

	PAIN DURING STAIR CLIMBING	
	YES	NO
a)	19	5
b)	12	12

TABLE 4

Statistical Results for Pain During Stair Climbing as it Compares to the Intraosseous Venous Pressure (IOVP), the Percentage IOVP is of the Mean Arterial Pressure (IOVP/MAP x 100), Presence of Cartilage Degeneration (PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	Student's t-test	1.68	0.2477
IOVP/MAP x 100	Student's t-test	1.68	0.5230
PFC	One-level χ^2	3.84	5.1242*

* significant $p<.05$

TABLE 5

Statistical Results for Rest Pain a) during the day, and b) during the night, as it Compares to the Presence of Cartilage Degeneration (PFC), the Intraosseous Venous Pressure (IOVP), and the Percentage that IOVP is of the Mean Arterial Pressure (IOVP/MAP x 100).

VARIABLE	TEST	CRITICAL VALUE	RESULT
a) Day vs: PFC	One-level χ^2	3.84	1.34
IOVP	Student's t-test	1.68	0.61
IOVP/MAP x 100	Student's t-test	1.68	1.08
b) Night vs: PFC	One-level χ^2	3.84	3.20
IOVP	Student's t-test	1.68	0.22
IOVP/MAP x 100	Student's t-test	1.68	0.26

TABLE 6

Statistical Results for Clicking as it Compares to Intraosseous Venous Pressure (IOVP), the Percentage that the IOVP is of the Mean Arterial Pressure (IOVP/MAP x 100), and the Presence of Cartilage Degeneration (PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	Student's t-test	1.68	0.4201
IOVP/MAP x 100	Student's t-test	1.68	0.4245
PFC	One-level χ^2	3.84	2.4000

TABLE 7

Statistical Results for Locking as it Compares to the Intraosseous Venous Pressure (IOVP), the Percentage that the IOVP is of the Mean Arterial Pressure(IOVP/MAP x 100), and the Presence of Cartilage Degeneration (PFC).

VARIABLES	TEST	CRITICAL VALUE	RESULT
IOVP	Student's t-test	1.68	0.2669
IOVP/MAP x 100	Student's t-test	1.68	0.0100
PFC	One-level χ^2	3.84	1.6134

TABLE 8

Statistical Results for Catching as it Compares to the Intraosseous Venous Pressure (IOVP), the Percentage that IOVP is of the Mean Arterial Pressure (IOVP/MAP x 100), and the Presence of Cartilage Degeneration (PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	Student's t-test	1.68	0.2409
IOVP/MAP x 100	Student's t-test	1.68	0.3229
PFC	One-level χ^2	3.84	0.0847

TABLE 9

Statistical Results for Giving Way as it Compares to the Intraosseous Venous Pressure (IOVP), the Percentage that IOVP is of the Mean Arterial Pressure (IOVP/MAP x100), and the Presence of Cartilage Degeneration (PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	Student's t-test	1.68	0.6364
IOVP/MAP x 100	Student's t-test	1.68	0.8145
PFC	One-level χ^2	3.84	0.0000

TABLE 10

Statistical Results for Pain Following Activity as it Compares to the Intraosseous Venous Pressure(IOVP), the Percentage that the IOVP is of the Mean Arterial Pressure (IOVP/MAP x 100), and the Presence of Cartilage Degeneration (PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	Student's t-test	1.68	0.3701
IOVP/MAP x 100	Student's t-test	1.68	0.5369
PFC	One-level χ^2	3.84	2.0221

TABLE 11

Statistical Results for Pain While Sitting With Knees Flexed as it Compares to the Intraosseous Venous Pressure (IOVP), the Percentage that the IOVP is of the Mean Arterial Pressure (IOVP/MAP x 100), and the Presence of Cartilage Degeneration (PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	Student's t-test	1.68	0.6276
IOVP/MAP x 100	Student's t-test	1.68	0.8464
PFC	One-level χ^2	3.84	1.7778

C. Signs

Pain on Compression

Pain with compression of the patella at twenty degrees of knee flexion was statistically significant of the presence of cartilage degeneration at the .05 level. However, the IOVP and the IOVP/MAP x 100 values displayed no significant difference between groups that did and did not have pain during this test (Table 12). The values for the Chi-square test for patellar compression at twenty degrees flexion are shown in Table 13.

TABLE 12

Statistical Results for Pain on Patellar Compression at 20 Degrees as it Compares to the Intraosseous Venous Pressure (IOVP), the Percentage that the IOVP is of the Mean Arterial Pressure (IOVP/MAP x100), and the Presence of Cartilage Degeneration (PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	Student's t-test	1.68	0.8788
IOVP/MAP x 100	Student's t-test	1.68	0.9316
PFC	One-level χ^2	3.84	4.1481*

* significant p<.05

TABLE 13

Chi-Square Contingency Table for Patellar Compression
at 20 Degrees of Knee Flexion in
a) Subjects with Cartilage Degeneration, and
b) Subjects without Cartilage Degeneraton.

	PAIN ON COMPRESSION	
	YES	NO
a)	14	10
b)	7	17

Pain on patellar compression at zero degrees was not statistically significant with regard to the presence of cartilage degeneration (PFC), intraosseous venous pressure (IOVP) or the percentage that the IOVP was of the mean arterial pressure (IOVP/MAP x 100)(Table 14).

TABLE 14

Statistical Results for Pain on Patellar Compression at 0 Degrees as it Compares to the Intraosseous Venous Pressure (IOVP), the Percentage that the IOVP is of the Mean Arterial Pressure (IOVP/MAP x 100), and the Presence of Cartilage Degeneration (PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	Student's t-test	1.68	0.0105
IOVP/MAP x 100	Student's t-test	1.68	0.4076
PFC	One-level x^2	3.84	0.8788

Crepitus

The presence of cartilage degeneration (PFC) compared with the severity of crepitus on both passive and resisted movement in a two-level Chi-square test at the probability levels of .05 and .01 respectively. There was no significant difference in IOVP or IOVP/MAP x 100 values between severity levels for either of these two tests (Tables 15 &16). The values for the Chi-square analysis for these tests are shown in Tables 17 & 18.

The other signs did not demonstrate any statistically significant comparisons with the presence of cartilage degeneration, the intraosseous venous pressure, or the percentage that the intraosseous venous pressure was of the mean arterial pressure (Tables 19 through 25).

TABLE 15

Statistical Results for Crepitus During Passive Movement as it Compares to the Intraosseous Venous Pressure (IOVP), the Percentage that the IOVP is of the Mean Arterial Pressure(IOVP/MAP x 100), and Presence of Cartilage Degeneration (PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	One-way ANOVA	2.59	0.15
IOVP/MAP x 100	One-way ANOVA	2.59	0.28
PFC	Two-level χ^2	5.99	7.34*

* significant $p<.05$

TABLE 16

Statistical Results for Crepitus During Resisted Extension as it Compares to the Intraosseous Venous Pressure (IOVP), the Percentage that the IOVP is of the Mean Arterial Pressure (IOVP/MAP x 100), and the Presence of Cartilage Degeneration (PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	One-way ANOVA	2.59	0.41
IOVP/MAP x 100	One-way ANOVA	2.59	0.51
PFC	Two-level χ^2	α=.01, 9.21	13.81**

** significant $p<.01$

TABLE 17

Two-Level Chi-Square Contingency Table for Severity of Crepitus During Passive Knee Motion versus a) Subjects with Cartilage Degeneration, and b) Subjects without Cartilage Degeneration.

CREPITUS DURING PASSIVE MOVEMENT

	NONE	MILD	SEVERE
a)	3	16	5
b)	8	14	0

TABLE 18

Two-Level Chi Square Table for Severity of Crepitus During Resisted Extension of the Knee versus a) Subjects with Cartilage Degeneration, and b) Subjects without Cartilage Degeneration.

CREPITUS DURING RESISTED MOVEMENT

	NONE	MILD	[illegible]
a)	1	13	10
b)	6	16	0

TABLE 19

Statistical Results for Clarke's Sign at 0 Degrees as it Compares to Cartilage Degeneration (PFC), Intraosseous Venous Pressure (IOVP), and the Percentage that IOVP is of the Mean Arterial Pressure (IOVP/MAP x100).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	Student's t-test	1.68	0.6751
IOVP/MAP x 100	Student's t-test	1.68	0.7706
PFC	One-level χ^2	3.84	0.3750

TABLE 20

Statistical Results for Clarke's Sign at 20 Degrees of Flexion as it Compares to Intraosseous Venous Pressure (IOVP), the Percentage that the IOVP is of the Mean Arterial Pressure (IOVP/MAP x 100), and Presence of Cartilage Degeneration (PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	Student's t-test	1.68	0.9071
IOVP/MAP x 100	Student's t-test	1.68	0.9640
PFC	One-level χ^2	3.84	0.3829

TABLE 21

Statistical Results for Quadriceps Angle as it Compares to the Intraosseous Venous Pressure (IOVP), the Percentage that the IOVP is of the Mean Arterial Pressure (IOVP/MAP x 100), the Presence of Cartilage Degeneration (PFC), and the Grade of Chondromalacia (G of PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	Pearson r	0.243	-0.0689
IOVP/MAP x 100	Pearson r	0.243	0.0537
PFC	Student's t-test	1.68	0.6078
G of PFC:	One-way ANOVA	2.59	2.08
0 vs 1	Scheffe	10.36	2.1362
0 vs 2	Scheffe	10.36	0.2057
0 vs 3	Scheffe	10.36	2.3989
0 vs 4	Scheffe	10.36	5.2263
1 vs 2	Scheffe	10.36	0.7197
1 vs 3	Scheffe	10.36	0.1190
1 vs 4	Scheffe	10.36	2.8905
2 vs 3	Scheffe	10.36	1.3959
2 vs 4	Scheffe	10.36	4.2514
3 vs 4	Scheffe	10.36	1.4382
0 vs 1,2,3,4	Scheffe	10.36	7.2821
0,1 vs 2,3,4	Scheffe	10.36	3.9396
0,1,2 vs 3,4	Scheffe	10.36	5.4462
1 vs 2,3,4	Scheffe	10.36	1.3918
1,2 vs 3,4	Scheffe	10.36	4.2771

TABLE 22

Statistical Results for Genu Varum Alignment as it Compares to the Intraosseous Venous Pressure (IOVP), the Percentage that the IOVP is of the Mean Arterial Pressure (IOVP/MAP x 100), and the Presence of Cartilage Degeneration (PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	One-way ANOVA	3.21	0.97
IOVP/MAP x 100	One-way ANOVA	3.21	1.71
PFC	Three-level χ^2	7.82	0.10

TABLE 23

Statistical Results for Genu Valgum Alignment as it Compares to Intraosseous Venous Pressure (IOVP), the Percentage that the IOVP is of the Mean Arterial Pressure (IOVP/MAP x 100), and the Presence of Cartilage Degeneration (PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	One-way ANOVA	2.82	1.23
IOVP/MAP x 100	One-way ANOVA	2.82	0.77
PFC	Three-level χ^2	7.82	3.02

TABLE 24

Statistical Results for Genu Recurvatum as it Compares to Intraosseous Venous Pressure (IOVP), the Percentage that the IOVP is of the Mean Arterial Pressure, and the Presence of Cartilage Degeneration (PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	One-way ANOVA	2.82	2.47
IOVP/MAP x 100	One-way ANOVA	2.82	2.05
PFC	Three-level χ^2	7.82	0.88

TABLE 25

Statistical Results for Rotation as it Compares to Intraosseous Venous Pressure (IOVP), the Percentage that IOVP is of the Mean Arterial Pressure (IOVP/MAP x 100) and the Presence of Cartilage Degeneration (PFC).

VARIABLE	TEST	CRITICAL VALUE	RESULT
IOVP	One-way ANOVA	2.82	2.22
IOVP/MAP x 100	One-way ANOVA	2.82	2.10
PFC	Three-level χ^2	7.82	5.96

Chapter V

DISCUSSION

The purpose of the present study was to examine the difference in intraosseous venous pressure of the patella between grades of cartilage degeneration. It was also the intent of the author to see whether any of the signs and symptoms reported in the literature to aid in the clinical diagnosis of chondromalacia patellae were significant determiners in whether there was patellar cartilage degeneration or increased intraosseous venous pressure of the patella.

A. Intraosseous Venous Pressure

Contrary to the previous study by Bjorkstrom et al.[6], the data in this study did not show a significant difference in the patellar intraosseous venous pressure between grades of cartilage degeneration of the patella.

Bjorkstrom et al.[6] used menisectomy patients only as their control group whereas this study included patients with ligamentous instability as well. Early, grossly undetectable changes of the articular cartilage, or the underlying bone, may have already commenced in some of these unstable knees and may have influenced the results of this study.

Differing anesthetic between and within the two studies may have played significant roles in the intraosseous venous pressure values obtained. Azuma[17] demonstrated that certain drugs affected the intraosseous venous pressure, but these anesthetic agents also affected the systemic arterial pressure in a similar way. The present study measured the systemic arterial pressure concurrently with the intraosseous venous pressure and included these values in the analyses. However, no significant differences were found.

The intraosseous venous pressure measurement in the present study was performed from the lateral aspect of the patella to avoid damage to the distal fibers of the vastus medialis. In the study by Bjorkstrom et al.[4] the measurement needle entered the patella from the medial side. Differences in bony architecture and blood supply in the specific areas of measurement may exist between the two studies, thereby affecting the intraosseous venous pressure results.

Bjorkstrom et al.[4] had slightly different grading criteria for their study. However, these differences should not affect the results between the normal group and the combined degenerative cartilage groups. As can be seen in Appendix A, Bjorkstrom et al.[4] did not achieve statistical significance at the .05 level (Author's calculation) in this comparison. Analysis of variance between grades of cartilage degeneration displayed significance in their study. In the present study, there was no significance found. The only difference between Metcalf's[37] and Collin's[41] grading criteria is that Metcalf breaks up Collin's Grade 3 into his own Grades 3 and 4. Hence, there is one more group entered in the analysis when using Metcalf's classification and this factor in itself would lower the opportunity to achieve significance.

The mean age for the present study was 21.7 years while the mean age in the study done by Björkstrom et al.[6] was 27 years. It is possible, with the inclusion of the 30 to 40 year age range in the study by Bjorkstrom et al.[6], unlike the present study, that aging may be one of the key factors in the differences between the intraosseous pressures found in the two studies.

B. Signs and Symptoms

In an attempt to isolate a syndrome, the author chose signs and symptoms indicated in the literature to help in the clinical diagnosis of either patellar chondromalacic change or increased intraosseous venous pressures. The signs and symptoms which were found to occur significantly more frequently in patients with chondromalacic change of the patella would aid in the differential diagnosis of the patient with knee complaints. Due to the ethical constraints placed on the selection of subjects for the measurement of the intraosseous venous pressure, subjects who had no knee pathology could not be used for the comparison group. Therefore, the findings in this study have some clinical usefulness in that differential diagnosis is only necessary on symptomatic knees.

None of the signs or symptoms examined in this study were statistically significant of the values for the intraosseous venous pressure or the percentage that the intraosseous venous pressure was of the mean arterial pressure. Therefore, raised intraosseous venous pressure in patellae is not detectable using the signs and symptoms analysed in this study.

Symptoms

Pain During Stair Climbing

Pain experienced during ascending or descending stairs demonstrated a statistically significant comparison with the frequency of cartilage degeneration (Table 4). To the author's knowledge, there is no statistical examination of this symptom in the literature. All reports have been clinical impressions with, at most, percentages stated. However, on examining Table 3, although statistical significance at the .05 level of confidence was attained with a Chi-square analysis, there are still twelve false positives and five false negatives in the sample of forty-eight. In essence, this symptom is an indication that cartilage degeneration is more likely to exist but is not a good predictor.

Rest Pain

Pain experienced at rest during the day did not demonstrate a statistically significant comparison with any of the three variables.

Pain experienced at rest during the night, did not show significance when compared to the intraosseous venous pressure at the .05 level. Night pain was again not significant of cartilage degeneration at the .05 level, however, the probability was less than .10. This significance level for night pain may be consistent with Helal's[75] description of the venous pain in primary osteoarthritis:

> A dull aching or throbbing pain felt diffusely about the knee, usually worse towards the end of the day and persisting for a while after retiring to bed.

Helal's statement was based on clinical observation and not on a controlled study[40].

Clicking

The symptom of clicking did not demonstrate a statistically significant comparison with any of the three variables analysed. Therefore, it appears that clicking can be caused by other factors besides patellar cartilage degeneration. Reports in the literature include clicking as a symptom of patellar subluxation and dislocation[64] and pathological synovial plicae[27].

Locking

The complaint of locking of the knee did not compare significantly to any of the three variables. This lack of significance is consistent with reports in the literature[76,77] in that locking was more frequently indicative of meniscal pathology.

Catching

The symptom of catching demonstrated no significance with any of the three variables examined. This finding was not consistent with previous reports in the literature. Catching, or pseudolocking, has been described as one of the complaints indicative of patello-femoral joint pathology[1,19,57]. Perhaps catching occurs just as frequently in other knee joint pathologies[27].

Giving Way

Another symptom showing no statistical difference between groups for any of the three variables examined was the complaint of giving way (Table 9). Although this complaint is reported by one author to be a symptom of patello-femoral joint pathology[21], it is also described as a symptom of ligamentous instability in the knee by another author[78].

Pain Following Activity

Pain following activity did not demonstrate statistical significance when analysed with regard to the three variables. These findings were contrary to reports in the literature. From Helal's[40] description of venous pain, one would suspect that activity increased the intraosseous venous pressure. Also, in most reports on chondromalacia patellae, this symptom is considered to help differentiate chondromalacia patellae from other knee pathology. Perhaps if the definition of activity in this study had been more specific to high patello-femoral joint loading activities, the results would differ. Also, the subject population was limited in the activities they had performed over the preceding months when examined preoperatively due to the avoidance of aggravating activities as part of their conservative treatment.

<u>Pain While Sitting With the Knees Flexed</u>

The "movie sign", or pain experienced while sitting with the knees flexed for a prolonged period of time, did not demonstrate statistical significance when compared to the three variables examined. Although this symptom was commonly described in the literature as an indication of patello-femoral joint pathology[20], perhaps it does not actually differentiate pathology of this joint from other knee joint pathologies.

Signs

Three of the clinical signs assessed demonstrated statistical significance at the .05 level of confidence when compared to the presence of patellar articular cartilage degeneration.

Patellar Compression at 20 Degrees Flexion

Pain experienced by the patient when the patella was compressed against the femoral trochlea with the knee flexed to twenty degrees was statistically significant at the .05 level when compared to the presence of cartilage degeneration on the patella (Tables 12 & 13). When this test was performed with the knee relaxed in extension (zero degrees flexion), the results were not significant (Table 14). These results were consistent with the recent trend in the literature[15] now describing this test in varying degrees of flexion rather than in full extension.

Crepitus

The severity of crepitus during both passive and resisted knee motion was statistically significant of cartilage degeneration at the .05 and .01 levels respectively (Tables 15 - 18). On closer examination of Tables 17 and 18, one can see that a mild amount of crepitus did not differentiate between the presence and absence of cartilage degeneration. However, either no crepitus or severe crepitus during either passive or resisted movement of the knee, was significant of the absence or presence of cartilage degeneration respectively. Reports in the literature vary in their opinion of the validity of crepitus as a clinical sign in differential diagnosis of the knee[1,20]. The important detail in the results of this study is the severity of the crepitus, with only absence of, or gross crepitus, being significant.

Dynamic Patellar Compression

Clarke's Sign, or the dynamic patellar compression test, performed at either twenty or zero degrees of flexion was not statistically significant for any of the three variables. Perhaps greater angles of flexion, as suggested by Malek et al.[56] and Malone[77], would give different results. However, this author had difficulty performing the test reliably at angles greater than twenty degrees.

Alignment

None of the alignment categories analysed (Q-angle, valgus, varus, recurvatum or rotation) demonstrated statistical significance to any of the three variables. These results are contrary to the clinical observations reported in the literature[46,49,50,61]. However, in another study[54] performed on a large population, alignment did not appear to predispose individuals to anterior knee pain.

Chapter VI

SUMMARY AND CONCLUSIONS

The main purpose of the present study was to assess the difference in the intraosseous venous pressure of the patella between grades of cartilage degeneration on the retropatellar surface. The second purpose of the study was to assess the difference in the aforementioned variables between groups exhibiting various levels of the following clinical signs and symptoms : clicking, locking, catching, giving way, pain during stair climbing, pain while sitting with the knees flexed, pain following activity, pain at rest during the day or night, alignment, retropatellar compression, dynamic patellar compression, quadriceps angle, and crepitus.

The clinical signs and symptoms were assessed the day prior to surgery and the intraosseous venous pressure measurement and cartilage grading were evaluated at the time of surgery. The subjects ranged in age from fifteen to thirty years and were categorized by the grade of cartilage degeneration on their patellae according to the classification of Metcalf[17].

One-way analysis of variance was performed to examine the difference in the intraosseous venous pressure between grades of the cartilage degeneration, between alignment variables, and between severity levels of crepitus. The difference in the quadriceps angle between grades of cartilage degeneration was analysed also using a one-way ANOVA.

The difference in the intraosseous venous pressure between groups with and without other clinical signs and symptoms was analysed with Student's t-tests. The frequencies of all signs and symptoms were compared to the presence or absence of cartilage degeneration using one-, two- or three-level Chi-square tests.

The relationship between the quadriceps angle and the intraosseous venous pressure was analysed using a Pearson Product Moment correlation coefficient.

In accordance with the limitations and delimitations imposed on this study, the intraosseous venous pressure of the patella did not prove to be significantly different between grades of cartilage degeneration or between levels of any of the clinical signs and symptoms examined. These results are not in agreement with the first and second hypotheses set forth prior to conducting this study.

The existence of patellar cartilage degeneration compared significantly at the .05 level to the frequency of occurrence of pain experienced while ascending or descending stairs, and to the frequency of pain with patellar compression at twenty degrees of knee flexion. The severity of crepitus during both passive and resisted movement proved to be significant of cartilage degeneration at the .01 and .05 levels of confidence respectively. These results support these parts of the third hypothesis set forth prior to conducting the study.

A. Conclusions

With the data available from the present study, the following conclusions were made :

1. The intraosseous venous pressure of the patella was not significantly different between grades of patellar cartilage degeneration.
2. The intraosseous venous pressure of the patella was not significantly different between groups with or without any of the signs or symptoms analysed.
3. The frequency of positive clinical findings in the following signs and symptoms : 1) pain while stair climbing, 2) pain with patellar compression at twenty degrees of flexion, and 3) severe crepitus during both passive and resisted knee motion, were significant when subjects with cartilage degeneration were compared to those with grossly normal articular cartilage.

The results of this study suggest that degenerative changes on the patellar articular cartilage do not compare consistently with the intraosseous venous pressure of the patella. Rest pain does not appear to indicate increased intraosseous venous pressure of the patella. This study strongly suggests that in the differential diagnosis of knee pain, few of the signs and symptoms reported in the literature help differentiate between other knee pathology and true chondromalacia patellae.

B. Recommendations

The major recommendations that can be made from the current study are as follows :

1. Further research should be performed before fenestration is used for treatment in retropatellar pain.
2. A controlled study should be performed to establish normative data for Q-angle measurement in several of the described positions now present in the literature. Following the completion of that study, an attempt should be made to correlate deviations from the norm with patello-femoral pain.

REFERENCES

REFERENCES

1. Insall J : Current concepts review. Patellar pain. The Journal of Bone and Joint Surgery 64 : 147-152, 1982.

2. Radin EL : A rational approach to the treatment of patello-femoral pain. Clinical Orthopaedics and Related Research 144 : 107-109, 1979.

3. Arnoldi CC, Linderholm M, Mussbichler H : Venous engorgement and intraosseous hypertension in osteoarthritis of the hip. The Journal of Bone and Joint Surgery 54-B : 409-421, 1972.

4. Lemperg RK, Arnoldi CC : The significance of intraosseous venous pressure in normal and diseased states with special reference to the intraosseous engorgement-pain syndrome. Clinical Orthopaedics and Related Research 144 : 107-109, 1978.

5. Lynch JA : Venous abnormalities and intraosseous hypertension associated with osteoarthritis of the knee. IN The Knee Joint, Amsterdam, Excerpta Medica, 1974, pp 87-92.

6. Bjorkstrom S, Goldie IF, Wetterqvist H : Intramedullary pressure of the patella in chondromalacia. Archives of Orthopaedic and Traumatic Surgery 97 : 81-85, 1980.

7. Ficat RP, Hungerford DS : Disorders of the Patello-Femoral Joint. London, Williams & Wilkins, 1974, p 124, 149.

8. Waisbrod H, Treiman N : Intraosseous venography in patello-femoral disorders : a preliminary report. The Journal of Bone and Joint Surgery 64-B : 454-456, 1980.

9. Bjorkstrom S, Goldie IF : A study of the arterial supply of the patella in the normal state, in chondromalacia and in osteoarthrosis. Acta Orthopaedica Scandinavica 51 : 63-70, 1980.

10. Brookes M, Helal B : Primary osteoarthritis, venous engorgement and osteogenesis. The Journal of Bone and Joint Surgery 550-B : 493-504, 1968.

11. Townsend PR, Rose RM, Radin EC, Raux P : The biomechanics of the human patella and its implications for chondromalacia. Journal of

Biomechanics 10 : 403-407, 1977.

12. Weightman B, Chappell DJ, Jenkins EA : A second study of tensile fatigue properties of human articular cartilage. Journal of Biomechanics 12 : 699-711, 1979.

13. Langer cited in Azuma H : Intraosseous pressure as a measure of hemodynamic changes in the bone marrow. Angiology 15 : 396-406, 1964.

14. Azuma H : Intraosseous pressure as a measure of hemodynamic changes in the bone marrow. Angiology 15 : 396-406, 1964.

15. Hoke B, Howell D, Stack M : The relationship between isokinetic testing and dynamic patellofemoral compression. Journal of Orthopaedic and Sports Physical Therapy 4 : 150-153, 1983.

16. Cary GC : Methods for determining the presence of subtle knee joint effusion. Journal of Louisiana State Medical Society 118 : 147-149, 1966.

17. Metcalf RW : Arthroscopic Surgery of the Knee : Instruction Manual. Salt Lake City, 1982.

18. Bentley G : Chondromalacia patellae. The Journal of Bone and Joint Surgery 52-A : 221-232, 1970.

19. Outerbridge RE, Dunlop JAY : The problem of chondromalacia patellae. Clinical Orthopaedics and Related Research 110 : 177-196, 1975.

20. Goodfellow J, Hungerford DS, Woods C : Patello-femoral joint mechanics and pathology. 2. Chondromalacia patellae. The Journal of Bone and Joint Surgery 58-B : 291-299, 1976.

21. Reider B, Marshall JL, Ring B : Patellar tracking. Clinical Orthopaedics and Related Research 157 : 143-152, 1981.

22. Stougard J : Chondromalacia of the patella. Acta Orthopaedica Scandinavica 46 : 685-694, 1975.

23. Kulowski J : Chondromalacia of the patella. Journal of the American Medical Association 100 : 1837-1840, 1933.

24. Davies GJ, Larson R : Examining the knee. The Physician and Sports Medicine 6 : 49-67, 1978.

25. Insall J, Falvo KA, Wise DW : Chondromalacia patellae. A

prospective study. The Journal of Bone and Joint Surgery 58-A : 1-8, 1976.

26. Darracott J, Vernon-Roberts B : The bony changes in "chondromalacia patellae". Rheumatology and Physical Medicine 11 : 175-179, 1971.

27. Vaughan-Lane T, Dandy DJ : The synovial shelf syndrome. The Journal of Bone and Joint Surgery 64-B : 475-476, 1982.

28. Magee DJ : Orthopaedics. Conditions, Assessment and Treatment. 4th ed. Edmonton, The University of Alberta. 1982.

29. Goodfellow J, Hungerford DS, Zindel M : Patello-femoral joint mechanics and pathology. The Journal of Bone and Joint Surgery 58-B : 287-290, 1976.

30. Minns RJ, Birnie AJM, Abernathy PJ : A stress analysis of the patella, and how it relates to patellar articular lesions. Journal of Biomechanics 12 : 699-711, 1979.

31. Goodfellow JW, Bullough PG : The pattern of ageing of the articular cartilage of the elbow joint. The Journal of Bone and Joint Surgery 49-B : 175-181, 1967.

32. Outerbridge RE : Further studies on the etiology of chondromalacia patellae. The Journal of Bone and Joint Surgery 46-B : 179-190, 1964.

33. Emery IH, Meachim G : Surface morphology and topography of the patellofemoral cartilage fibrillation in Liverpool necropsies. Journal of Anatomy 116 : 103-120, 1973.

34. Mow VC, Roth V, Armstrong CG : Biomechanics of joint cartilage. IN Basic Biomechanics of the Skeletal System. Frankel V, Nordin M (eds.) Philadelphia, Lea & Febinger, 1980, p 77.

35. Lund F, Nilsson BE : Arthroscopy of the patello-femoral joint. Acta Orthopaedica Scandinavica 51 : 297-302, 1980.

36. Reilly DT, Martens M : Experimental analysis of the quadriceps muscle force and patello-femoral joint reaction force for various activities. Acta Orthopaedica Scandinavica 43 : 126-137, 1972.

37. Pedley RB, Meachim G : Topographical variation in patellar subarticular calcified tissue density.

Journal of Anatomy 128 : 737-745, 1979.

38. Radin EL, Abernathy PJ, Townsend PM, Rose RM : The role of bone changes in the degeneration of articular cartilage in osteoarthritis. Acta Orthopaedica Belgica (Brussels) 44 : 55-63, 1978.

39. Arnoldi CC, Lemperg RK, Linderholm H : Intraosseous hypertension and pain in the knee. The Journal of Bone and Joint Surgery 57-B : 360-363, 1975.

40. Helal B : The pain in primary osteoarthritis of the knee. It's causes and treatment by osteotomy. Postgraduate Medical Journal 41 : 172-181, 1965.

41. Collins DH : Pathology of articular and spinal diseases. Baltimore, Williams and Wilkins Co., 1949.

42. Ficat RP, Ficat C, Gedeon P, Toussaint JB : Spongialization : A new treatment for diseased patellae. Clinical Orthopaedics and Related Research 144 : 74-83, 1979.

43. Morscher E : Osteotomy of the patella in chondromalacia. Archives of Orthopaedic and Traumatic Surgery 92 : 139-147, 1978.

44. Williams JGP : The foot and chondromalacia - A case of biomechanical uncertainty. The Journal of Orthopaedic and Sports Physical Therapy 2 : 50-51, 1980.

45. Fox TA : Dysplasia of the quadriceps mechanism. Surgical Clinics of North America 55 : 199-226, 1975.

46. Brown DE, Alexander AH, Lichtman DM : The Elmslie-Trillat procedure : Evaluation in patellar dislocation and subluxation. The American Journal of Sports Medicine 12 : 104-109, 1984.

47. Carson WG, James SL, Larson RL, Singer KM, Winternitz WW : Patellofemoral disorders : Physical and radiographic evaluation. Clinical Orthopaedics and Related Research 185 : 165-177, 1984.

48. Wiberg G : Roentgenographic and anatomic studies on the femoro-patellar joint. Acta Orthopaedica Scandinavica 12 : 319-410, 1941.

49. Huberti HH, Hayes WC : Patellofemoral contact pressures. The Journal of Bone and Joint Surgery 66 : 715-724, 1984.

50. Turner MS, Smillie IS : The effect of tibial torsion on

the pathology of the knee. The Journal of Bone and Joint Surgery 63-B : 396-398, 1981.

51. Staheli LT, Corbett M, Wyss C, King H : Lower-extremity rotational problems in children. The Journal of Bone and Joint Surgery 67 : 39-47, 1985.

52. James SL : Chondromalacia of the patella in the adolescent. IN The Injured Adolescent Knee. Kennedy JC (ed.) London, Williams and Wilkins, 1979, pp 214-217.

53. Larson RL : Fractures and dislocations of the knee. Part II. Dislocations and ligamentous injuries of the knee. IN Fractures. Vol 2, Rockwood CA, Green RP (eds.) Philadelphia, JP Lippincott Co., 1975, p 1200.

54. Fairbank JCT, Pynsent PB, van Poortvliet JA, Phillips H : Mechanical factors in the incidence of knee pain in adolescents and young adults. The Journal of Bone and Joint Surgery 66-B : 685-693, 1984.

55. Aglietti P, Insall JN, Cerulli G : Patellar pain and incongruence. I. Measurements of incongruence. Clinical Orthopaedics and Related Research 176 : 217-224, 1983.

56. Malek M, Mangine RE : Patellofemoral pain syndromes : A comprehensive and conservative approach. The Journal of Orthopaedic and Sports Physical Therapy 2 : 108-116, 1981.

57. Henry JH, Craven PR : Surgical treatment of patellar instability : Indications and results. The American Journal of Sports Medicine 9 : 82-85, 1981.

58. Knight JL : Chondromalacia patellae : Review of anatomy, biomechanics and histology with mention of new technique documenting lateral tracking. Orthopaedic Review 7 : 129-137, 1978.

59. Insall J, Salvati E : Patellar position in the normal knee joint. Radiology 101 : 101-104, 1971.

60. Lancourt JE, Cristini JH : Patella alta and patella infra. The Journal of Bone and Joint Surgery 57 : 1112-1115, 1975.

61. Dersheid GL, Malone TR : Knee disorders. Physical Therapy 60 : 1582-1589, 1980.

62. Larson RL, Cabaud HE, Slocum DB, James SL, Keenan T, Hutchinson T : The patellar compression syndrome.

Surgical treatment by lateral retinacular release. Clinical Orthopaedics and Related Research 134 : 158-167, 1978.

63. Wise HH, Fiebert IM, Kites JL : EMG biofeedback as treatment for patellofemoral pain syndrome. The Journal of Orthopaedic and Sports Physical Therapy 6 : 95-103, 1984.

64. Reider B, Marshall JL, Warren RF : Clinical characteristics of patellar disorders in young athletes. The American Journal of Sports Medicine 9 : 270-274, 1981.

65. Micheli LJ, Staniski CL : Lateral patellar retinacular release. The American Journal of Sports Medicine 9 : 330-336, 1981.

66. Insall J : Chondromalacia patellae : patellar malalignment syndrome. Orthopaedic Clinics of North America 10 : 117-127, 1979.

67. Hoppenfeld S : Physical Examination of the Spine and the Extremities. New York, Appleton-Century-Crofts, 1976, p 194.

68. Robinson AR, Darracott J : Chondromalacia patellae. Annals of Physical Medicine 10 : 286-290, 1970.

69. Levine J : Chondromalacia patellae. The Physician and Sportsmedicine 7 : 39-49, 1979.

70. Schneider D : Arthroscopy and arthroscopic surgery in patellar problems. Orthopaedic Clinics of North America 13 : 407-413, 1981.

71. Jackson RW : Surgery of the patellofemoral joint. Part II. Examination of the patella. IN Instructional Course Lectures. Volume 25, American Academy of Orthopaedic Surgeons 1976, p 31.

72. Bunger C, Harving S, Bunger EH : Intraosseous pressure in the patella in relation to simulated joint effusion and knee position. Acta Orthopaedica Scandinavica 53 : 745-751, 1982.

73. American Heart Association : Recommendations for Human Blood Pressure Determination by Sphygmomanometer. American Heart Asssociation, 1967.

74. Ferguson GA : Statistical Analysis in Psychology and Education. 4th ed. Toronto, McGraw-Hill Inc., 1976.

75. Helal B : The pain in primary osteoarthritis of the

knee. It's causes and treatment by osteotomy. Postgraduate Medical Journal 41 : 172-181, 1965.

76. Cyriax J : Textbook of Orthopaedic Medicine. Vol 1, 7th ed. London, Bailliere Tindall, 1978, p 634.

77. Salter RB : Textbook of Disorders and Injuries of the Musculoskeletal System. London, Williams and Wilkins, 1970, p 514.

78. Roy S, Irvin R : Sports Medicine. Prevention, Evaluation, Management, and Rehabilitation. Englewood Cliffs, New Jersey, Prentice-Hall, 1983, p 307.

79. Malone T cited in Hoke B, Howell D, Stack M : The relationship between isokinetic testing and dynamic patellofemoral compression. Journal of Orthopaedic and Sports Physical Therapy 4 : 150-153, 1983.

APPENDIX A

Statistical Analysis of Raw
Data From Bjorkstrom et al.†

TABLE A

Group Classification, Size, Means, and Ranges of Intraosseous Venous Pressure for Bjorkstrom, Goldie, and Wetterqvist †.

GROUP	n	MEAN (mm Hg)	RANGE (mmHg)
PFC 1	3	41	26-60
PFC 2	7	37	21-60
PFC 3	3	64	48-86
O A	3	37	15-74
Control	13	19	4-42

----

† Bjorkstrom S, Goldie IF, Wetterqvist H : Intramedullary pressure of the patella in chondromalacia. Acta Orthopaedica Scandinavica 97 : 81-85, 1980.

TABLE B

Statistical Tests and Results Calculated from Raw Data Presented in Bjorkstrom, Goldie and Wetterqvist †.

GROUP	TEST	CRITICAL VALUE	RESULT
PFC vs Control	Student's t-test	1.71 α=.05	1.6495
0,1,2,3	One-way ANOVA	4.82 α=.01	9.46**
0 vs 1	Scheffe	14.46 α=.01	5.75
0 vs 2	Scheffe	9.15 α=.05	7.29
0 vs 3	Scheffe		24.80**
1 vs 2	Scheffe		0.153
1 vs 3	Scheffe		4.07
2 vs 3	Scheffe		7.83

** significant $p<.01$

† These calculations were performed by the author for comparison with the results of the present study.

APPENDIX B

Knee Assessment Form

KNEE ASSESSMENT FORM (J. Wilson Nov. 1983)

Name		Subject #	Right	Left
Hospital #		Category Ligament	Acute	Chronic
DOB	Age	Menisectomy	Acute	Chronic
Height	Weight	P-F C LRR	TTT	Patellectomy

History

Duration of Symptoms (months)

Triggering Mechanisms - Growth spurt
- Increased activity
- External trauma

Comments

Prior Physical Therapy

Drug Therapy

Previous Knee Surgery

Symptoms

Clicking — Catching (Pseudo-locking)

Locking — Giving way

Pain

On climbing stairs

On sitting with knees flexed

Following activity

Rest Pain

Day — Relieved by ice

Night — Relieved by heat

Swelling

None	Occasional (heavy activity)	Frequent (daily activity)	Constant

Examination

Varus	None	Mild	Moderate	Severe
Valgus	None	Mild	Moderate	Severe
Recurvatum	None	Mild	Moderate	Severe
Rotation	None	Mild	Moderate	Severe
	Medial		Lateral	

Retropatellar pain on pressure

20° flexion	Yes	No
0° flexion	Yes	No

Clarke's Sign

20° flexion	Positive	Negative
0° flexion	Positive	Negative

Effusion	None	Mild	Moderate	Severe
Atrophy	None	1-2 cm	2 cm +	
	(L=	R=)		

Quadriceps angle

Range of Motion

Sitting

Full & Painfree	Full with pain in last 20° extension	Limited extension (degrees)

Supine

Full & Painfree	Full with pain in last 20° flexion	Limited flexion (degrees)

Resisted ROM (maximal manual in sitting)

Painfree	Pain between 45°&0°
Pain between 90°&45°	Pain throughout ROM

Crepitus

Passive	None	Mild	Severe
Resisted	None	Mild	Severe

Squatting

No pain

Pain	0°-30°	30°-60°
	60°-90°	90°+

Instability

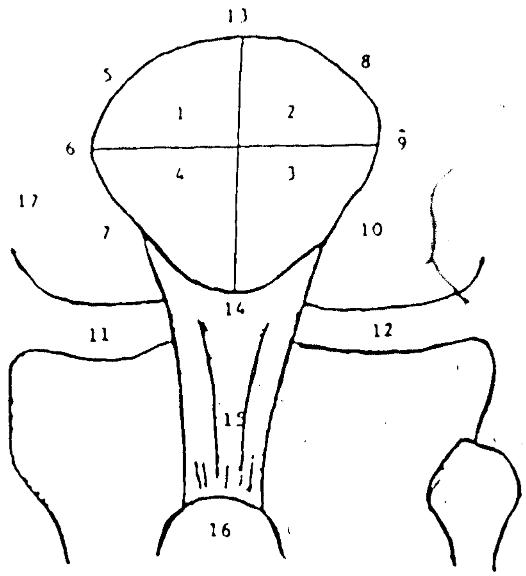
Valgus Stress	None	Mild	Severe
Varus Stress	None	Mild	Severe
Lachman's Test	None	Mild	Severe
Anterior Drawer	None	Mild	Severe
Posterior Drawer	None	Mild	Severe
Pivot Shift	None	Mild	Severe

McMurray's Test

Positive (Click & Pain) Equivocol (Click or Pain) Negative

Palpation

MEDIAL



LATERAL

Radiological Findings

Sulcus Angle

Congruence Angle

Lateral Patellar Displacement

Laurin's Angle

PT/P Ratio

Shape

Anesthetic Agents

Systemic Blood Pressure

Intraosseous Venous Pressure

Patella

Tibia

Cartilage Degeneration Grade

Location

APPENDIX C

Outline of Procedures

INTRAOSSEOUS VENOUS PRESSURE IN CHONDROMALACIA PATELLAE

OUTLINE OF PROCEDURES (retained by subject)

Recent articles in the medical literature have indicated that increased pressure within the patella (kneecap) may be one of the contributing factors in the pain experienced by people suffering from chondromalacia patellae (softening of the cartilage on the back of the kneecap). Although numerous studies have been done investigating this aspect in the condition of osteoarthritis (degenerative joint disease), only a small amount of data has been collected for chondromalacia patellae.

Since many people suffer from chondromalacia, it is essential that more information is obtained about its causes so the most appropriate treatment may be given to achieve pain relief.

The study in which you are being requested to participate will measure the pressure inside the patella (kneecap) of the knee in which you are about to have surgery.

The investigators in this study will be measuring pressures in patellae (kneecaps) of people undergoing knee surgery for various reasons. One group consists of people with the diagnosis of chondromalacia; the second group consists of people having surgery for a) removal of a torn meniscus (cartilage) or b) repair of torn ligaments.

Once you are anesthetized (asleep) for your operation, a needle will be entered into your patella to a depth of approximately 2 cm so the pressure measurement may be done. When this has been completed your operation will be performed.

The risk of additional pain beyond that from your original operation is minimal. This procedure has been carried out on many patients with osteoarthritis and no complaints have been reported.

Risk of infection will be minimal as this procedure is being carried out under the same sterile conditions as any surgery is performed.

All records and photographs will be the property of the investigators. No records or photographs which would permit your identification will be made public and/or used in a medical publication without your written consent to do so. Access to all records will be restricted to those individuals associated with the investigation.

In the event that further questions arise concerning the study, please feel free to contact the investigators: Dr. D.C. Reid (432-6233) or J. Wilson (433-0849).

Should you decide, at any time, to withdraw from the study, this will in no way influence the medical care you receive.

Please retain this explanation for your own records.

APPENDIX D

Release Form

University of Alberta November 1983

Faculty of Rehabilitation Medicine Department of Physical Therapy

Faculty of Medicine Department of Surgery

INFORMED CONSENT FORM FOR INVESTIGATIVE STUDY

INTRAOSSEOUS VENOUS PRESSURE IN CHONDROMALACIA PATELLAE

SUBJECT CONSENT (retained by investigators)

I..........................do hereby agree to participate as a subject in the study entitled "Intraosseous Venous Pressure in Chondromalacia Patellae" to be conducted by Dr. D.C. Reid and J. Wilson. The nature of the study has been explained to me and I understand that it is not intended as a form of remedial treatment for any condition which I may have. I have been advised that I may withdraw my participation at any time without influencing the medical care I receive.

....

Subject's Signature Date

(Parent or Legal Guardian if under 18)

....

Address Phone Number

I was witness during the explanation referred to above and to the signature.

....

Witness Signature Date

APPENDIX E

Correlation of Reliability

Correlation of Reliability

Pearson product moment correlation coefficient, comparing the author's measures of systemic blood pressure by auscultation to those of a designated expert, were performed using the following equation :

$$r = \frac{N \Sigma XY - \Sigma X \Sigma Y}{\sqrt{[N \Sigma X^2 - (\Sigma X)^2][N \Sigma Y^2 - (\Sigma Y)^2]}}$$

Ferguson 1976 †

---

† Ferguson GA : Statistical Analysis in Psychology and Education. 4th ed. Toronto, McGraw-Hill Inc., 1976.

In Table C, X represents the expert's measurements and Y represents the author's measurements. The r equals the Pearson Product Moment Correlation Coefficient value obtained and the p is the significance of the correlation value.

TABLE C

Correlation of Reliability for Blood Pressure Measurement by Auscultation.

SYSTOLIC		DIASTOLIC		MEAN	
X	Y	X	Y	X	Y
150	148	80	80	103.1	102.4
132	130	88	86	102.5	100.5
120	124	70	74	86.5	90.5
120	118	70	72	86.5	87.2
124	122	80	82	94.5	95.2
90	90	52	54	64.5	65.9
110	110	70	68	83.2	81.9
112	120	64	68	79.8	85.2
112	112	68	68	82.5	82.5
140	138	70	72	93.1	93.8
140	138	88	84	105.2	101.8
130	128	70	72	89.8	90.5
$r = .98$		$r = .97$		$r = .98$	
$p<.001$		$p<.001$		$p<.001$	

The measurement of quadriceps angle by the author was repeated on fourteen individuals at a one week interval. In Table D, X represents the initial measurement and Y represents the measurement when it was repeated after one week.

TABLE D

Correlation of Reliability for Quadriceps Angle Measurement

X	Y
28	27
26	29
23	25
20	24
16	18
19	16
18	21
13	11
16	20
17	15
20	18
16	15
17	16
21	20

$r = 0.876$

$p<.005$