RESEARCH PROPOSAL

“ANTERIOR CRUCIATE LIGAMENT: ANATOMY, SYMPTOMS AND RECONSTRUCTION”

NUMBER OF WORDS: **1857**

Contents

Title

Anterior cruciate ligament: anatomy, symptoms and reconstruction

Background

General introduction. Located in the centre of the knee, the anterior cruciate ligament (ACL) is a strong band of tissue that prevents the shin bone (tibia) from extending excessively beyond the thigh bone (femur). The ACL provides almost 90% of the stability to the knee joint and experiences dramatic surcharges during people's physical activity. As a result, ACL injuries appear common and usually sports-related traumas. Almost any sport that involves jumping, cutting or twisting has an inherent risk of an ACL rupture. However, in modern medicine these kinds of injuries are especially associated with such events as basketball, football, volleyball, tennis and skiing where the loading on ACL increases in dozens times. Due to the achievements of modern surgery today's athletes have greater than a 90% chance of returning to their pre-injury level of sports participation.

Anatomy. There are four primary stabilizers of the knee, i.e.: ACL, the PCL (Posterior Cruciate Ligament), the MCL (Medial Collateral Ligament) and the LCL (Lateral Collateral Ligament). These ligaments function in concert with the muscles and cartilage of the knee to help control motion. Proprioceptive (nerve) fibers in these ligaments and the capsule of the knee joint augment this control via reflex feedback. The anterior cruciate ligament and the medial collateral ligament are most often injured in sports.

A knee without an ACL may show signs of instability, with unsettling episodes of unpredictable knee motion during cutting (running with sudden changes of direction), jumping, or running up or down hills. Such episodes put the menisci ("C"-shaped cartilage rings that serve as bumpers between the thigh and leg bones) at risk for injury. Children and adolescents with anterior cruciate deficient knees will typically end up competing at a lower activity level than pre-injury. Also, despite the use of specially designed braces, additional knee injuries during play can occur.

ACL injures occurrence. According to medical statistic, ACL ruptures occur at a rate of 60 per 100.000 people per year in the United States. With society's growing interest in physical activities the scientists expect dramatic growth of ACL related traumas in an early date. As a result, there is a strong necessity to provide an all-round understanding of the ACL injury itself (its anatomy, major reasons of traumas and their prevention, etc.) as well as evaluate the methods that are beneficial in treatment of ACL injuries.

Injuries to the ACL can occur in a number of situations, including sports, and can be quite serious, requiring surgery. An ACL injury may result from a violent, twisting motion (deceleration, valgus, rotation) of the knee, which can occur when an athlete plants his or her foot and suddenly changes direction. The ACL can also tear if the knee is 'hyperextended' (bent backwards).

There are several major identified reasons of ACL injures. They are as following

- Sudden stops and twisting motions of the knee, or a force or "blow" to the front of the knee.
- The extent of the tear.
- Simultaneous injures of the other structures inside the knee joint.

Symptoms of ACL injure. If injured, the ACL usually has the following symptoms:

- Pain at the time of impact which dies away afterwards.
- Swelling.
- If the swelling comes on rapidly then it could be caused by bleeding within the joint.
- In the later stages when the swelling has decreased there might be instability in the joint.
- Pain when you bend the leg and have the tibia (lower leg bone) pulled forwards.

Classification of ligament injuries. ACL injures are usually graded in terms of their severity:

- *Grade I sprain* – some micro-tearing or slight stretching occurs, however the overall integrity of the ligament is preserved. The ligament hurts if stressed but is stable.
- *Grade II sprain* – partial disruption of the ligament. Painful to stress, there is detectable laxity but the ligament has an eventual endpoint.
- *Grade III tear* – complete ligament tear and laxity with no endpoint or stability to testing. As the nerves in the ligament are torn too, there is often minimal pain with stressing the joint.

Repair and reconstruction of ACL. ACL ***repair*** can be accomplished in selected tears where the ligament tissue is in good condition, the tear is close to the bone, and best if the patient is over 35 years old.

Surgical ***reconstruction*** of the ACL is indicated for patients with unstable knees who desire to remain active. We reconstruct the ligament with a graft from the patient's own knee or from a donor cadaver knee using a bone-patellar tendon-bone graft. When followed with an intensive rehabilitation program that we custom design for each patient the results are that 90% of patients can return to full sports with a stable knee. ACL reconstruction is a complex process and although the success rate is generally 85-95%, there are times when the reconstruction is unsuccessful.

Rehabilitation. The post-surgery recuperative period and rehabilitation program can be even more important than the surgery itself. Activities should be arranged to promote healing, upgrade flexibility in the knee, and strengthen surrounding muscles. A passive range of motion program (stretching) following surgery aids in the healing process, promotes better nutrient flow to the cartilage caps at the ends of the femur and tibia, and prevents excess tightness from developing in the knee. A hinged knee brace which prevents hyperextension or hyperflexion should be used during the four to six weeks after surgery in order to prevent ruptures of the new ACL (stretching activities take place without the brace on, however).

Research Aims

Generally, amidst all the anatomy, symptoms and reconstruction of the ACL this project will examine major reasons of ACL rupture amidst different groups of patient

with the primary focus on sportsmen. The present project is also targeted to evaluate major modern methods of ACL treatment and assess their effectiveness for different kinds of ACL traumas. The project will also explore a number of medical and, particularly, surgical problems related to the ACL.

The major objectives of this study are:

1. Identify the anatomy of ACL and assess the threats for its trauma amidst different layers of people.
2. Identify the key reasons of ACL rupture and evaluate their severity.
3. Recognize major symptoms of ACL and evaluate their prevalence.
4. Develop a list of most successful modern surgical and therapeutic methods of ACL treatment and evaluate their effectiveness.
5. Finally, recommend the methods how to treat ACL in different people (1), different levels of trauma's severity (2) and other related factors (3).

Literature Review

There's a list of modern as well as relatively old sources dedicated to the problem of ACL. These sources will be analyzed according to the following principle:

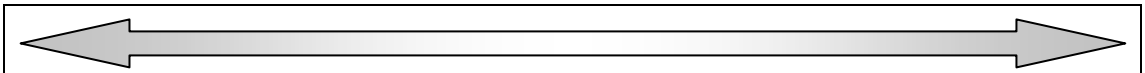
1. Monographs and research papers
2. Articles in medical journals
3. Internet articles and web-references

The papers will be also analyzed according to their contribution to the research field, comprehensiveness of the utilized approach, qualitative or quantitative researches, strengths and blond spots.

Research Design and Methodology

Having identified a research topic and done the preliminary literature review the next logical step is to chalk out the route map for the research project. Looking at the research process 'onion' (Saunders et. al., 2003) one can identify various approaches, strategies and data collection methods across the continuum of research philosophy.

Figure 1: **Elements across the continuum identified in the Research Process 'onion'**



Research Philosophy			
Positivism		Realism	Interpretivism
Research Approach			
Deductive			Inductive
Research Strategies			
Comprehensive medial survey	Analysis of case studies		Grounded Theory
Time Horizon			
Cross-Sectional			Longitudinal
Data Collection Methods			
Sampling	Secondary Data	Observation	Evaluation of the results

Source: adopted from the *research process 'onion'* by Saunders et. al. (2003)

Although choosing the research philosophy is dependent on the choice of strategic aims and hypotheses of the study, it would be misleading to prefer a single approach to the others. A combination of researches approaches often gives better results as it is often known. It can be illustrated by a following quote:

> *"Not only is it perfectly possible to combine approaches within the same piece of research, but…it is often advantageous to do so."*
>
> *(Saunders et. al., 2003)*

Since it is perfectly alright to combine approaches, it can be deduced that it is perfectly alright to 'mix and match' different research strategies with the different research approaches.

Data Collection Methods

Having decided upon the research strategies, the next step is to collect the data. Limited by the choice of time horizon, a lot of the data used in the research is likely to be **secondary** in nature. Typically secondary data are of the following types:

- Documentary – *written materials* or *non-written (media-based) materials*
- Multiple Source – *area based (e.g. journal, country)* or *time series based*
- Survey – *censuses*, *continuous & regular survey*, or *ad-hoc surveys*

These types of secondary information can be available in books, journal articles, newspapers & magazines, conference papers, reports, archives, films, television, electronic database, internet, etc.

The literature reviews would typically constitute the majority requirement of secondary data. Information regarding ACL anatomy, most probable reasons of traumas, ways of diagnosing and treatment as well as other vital information (required for furthering & supporting the analysis of findings from primary data) are the typical kinds of secondary data that would be used in the study. Such data are nowadays mostly available through the Internet. Alternatively, libraries are goods sources of books on leading theories and thinking of experts on the subject. In the present research we will generally lean on secondary data.

Analysis of Data and Interpretation of Findings

The data obtained through the various methods discussed above would be either **quantitative** or **qualitative**. Since the research is mostly *interpretivist* in nature, there is unlikely to be too many data that might require elaborate statistical analysis of quantitative data.

Quantitative analysis is more likely to be secondary and exploratory (or descriptive) in nature, summarising data in the form of charts, tables, percentages and averages. In the event that a survey is carried out, the data obtained would mostly be categorical, hence is likely to be ranked across a scale. This data might be represented in terms of frequency, central tendency or dispersion. It is highly unlikely the research might require the necessity of inferential data analysis.

Qualitative analysis of data is expected to be more frequently used within the research than its quantitative counterpart. Although there might be scope for a certain degree of quantifying some of the data, an overall non-quantifying method is likely to be used through the data analysis and interpretation process. This would involve *categorisation, 'unitising' data, recognising relationships and developing categories to facilitate it*, and *developing and testing hypotheses to reach conclusion*.

Conclusion

The final report project will have the following format:

1. Title
2. Research Question
3. Literature Review
4. Research Methodology
5. Conceptual Framework
6. Primary Research
7. Analysis
8. Findings
9. Conclusions & Recommendations
10. References
11. Appendices

BIBLIOGRAPHY:

1. Acasuso-Diaz, M., Collantes-Estevex, E. & Sanchez-Guijo, P. (1993). Joint hyperlaxity and musculo-ligamentous lesions: study of a population of homogeneous age, sex, and physical exertion. *British Journal of Rheumatology, 32,* 120-122.

2. Arendt, E. & Dick, R. (1995). Knee injury patterns among men and women in collegiate basketball and soccer. *American Journal of Sports Medicine, 23,* 694-701.

3. Aune AK, Holm I, Risberg MA, Jensen HK, Steen H. Four-strand hamstring tendon autograft compared with patellar tendon–bone autograft for anterior cruciate ligament reconstruction. *Am J Sports Med 2001;29*:722–728.

4. Barber FA. Tripled semitendinosus–cancellous bone anterior cruciate ligament reconstruction with bioscrew fixation. *Arthroscopy 1999;15*: 360–367.

5. Bjordal, J., et al. (1997). Epidemeology of anterior cruciate ligament injuries in soccer. *American Journal of Sports Medicine, 25(3),* 341-345.

6. Boszotta H. Arthroscopic reconstruction of anterior cruciate ligament using BTB patellar ligament in the Press-Fit technique. *Surg Technol Int 2003;11*:247-57.

7. Brand J, Weiler A, Caborn DN, Brown CH, Johnson DL. Graft fixation in cruciate ligament reconstruction. *Am J Sports Med 2000;28*: 761–774.

8. Clancy WG Jr, Narechania RG, Rosenberg TD, Gmeiner JG, Wisnefske DD, Lange TA. Anterior and posterior cruciate ligament reconstruction in rhesus monkeys. A histological microangiographic and biomechanical analysis. *J Bone Joint Surg (Am) 1981*;63:1270–

9. Clark R, Olsen RE, Larson BJ, Goble EM, Farrer RP. Cross-pin femoral fixation: a new technique for hamstring anterior cruciate ligament reconstruction of the knee. *Arthroscopy 1998*;14:258–267.

10. Cooper DE, Deng XH, Burstein AL, Warren RF. The strength of the central third patellar tendon graft: a biomechanical study. *Am J Sports Med 1993;21*:818–824.

11. Cox, J. & Heinz, W. (1984). Women midshipmen in sports. *American Journal of Sports Medicine, 12,* 241-243.

12. Ferretti, A., et al. (1992). Knee ligament injuries in volleyball players. *American Journal of Sports Medicine, 20,* 203-207.

13. Fink C, Benedetto KP, Hackl W, Hoser C, Freund MC, Rieger M. Bioabsorbable polyglyconate interference screw fixation in anterior cruciate ligament reconstruction: a prospective tomography controlled study. *Arthroscopy 2000;16*:491–498.

14. Garrick J. & Requa R. (1978). Girls' sports injuries in high school athletics. *Journal of the American Medical Association, 239,* 2245-2251

15. Gobbi A, Mahajan S, Zanazzo M, Tuy B. Patellar tendon versus quadrupled bone-semitendinosus anterior cruciate ligament reconstruction : *A prospective clinical investigation in athletes. Arthroscopy 2003;19(6):*592-601.

16. Godshall, R. (1992). The predictability of athletic injuries: An eight-year study. *Journalof Sports Medicine, 20,* 203-207.

17. Good, L., Odensten, M., & Gillquist J. (1991) Intercondylar notch measurements with special reference to anterior cruciate ligament surgery. *Clinical Orthopedics, 263,* 185-189.

18. Gray, J., et al. (1985). A survey of the injuries to the anterior cruciate ligament of the knee in female basketball players. *American Journal of Sports Medicine, 6,* 314-316.

19. Hamner DL, Brown CH Jr, Steiner ME, Hecker AT, Hayes WC. Hamstring tendon grafts for reconstruction of the anterior cruciate ligament: biomechanical evaluation of the use of multiple strands and tensioning techniques. *J Bone Joint Surg (Am) 1999*;*81*:549–557.

20. Hughston JC. Anterior cruciate deficient knee. *Am J Sports Med 1983;11*:1-2.

21. Huston, L. & Wojtys, E. (1996). Neuromuscular performance characteristic in elite female athletes. *American Journal of Sports Medicine, 24*, 427-436.

22. Hutchinson, M. & Ireland, M. (1995). Knee injuries in female athletes. Sports Medicine, 19, 288-302.

23. Ireland, M. (1994). Special concerns of the female athlete. In: Fu FH, Stone DA, eds.. *Sports Injuries: Mechanism, Prevention, and Treatment*. 2nd ed. Philadelphia, Pa: Williams & Wilkins, 153-187.

24. Johnson DP. Operative complications from the use of biodegradable Kurosaka screws. *J Bone Joint Surg (Br) 1998;(Suppl 1);*103.

25. Kannus P, Jarvinen M. Conservatively treated tears of anterior cruciate ligament. *J Bone Joint Surg 1987;69-A*:1007-12.

26. Kurosaka M, Yoshiya S, Andrish JT. A biomechanical comparison of different surgical techniques of graft fixation in anterior cruciate ligament reconstruction. *Am J Sports Med 1987*;15:225–229.

27. Lajtai G, Humer K, Aitzetmuller G, Unger F, Noszian I, Orthner E. Serial magnetic resonance imaging evaluation of a bioabsorbable interference screw and the adjacent bone. *Arthroscopy 1999*;15:481–488.

28. Lajtai G, Noszian I, Humer K, Unger F, Aitzetmuller G, Orthner E. Serial magnetic resonance imaging evaluation of operative site after fixation of patellar tendon graft with bioabsorbable interference screws in anterior cruciate ligament reconstruction. *Arthroscopy 1999*;15: 709–718.

29. LaPrade, R. & Quinter, M. (1994). Femoral intercondylar notch stenosis and correlation to anterior cruciate ligament injuries: a prospective study. *American Journal of Sports Medicine, 22,* 198-203.

30. Mayo Robson AW. Ruptured crucial ligaments and their repair by operation. *Ann Surg 1903;37*:716-8.

31. McDaniel W, Dameron TB. Untreated ruptures of the anterior cruciate ligament. *J Bone Joint Surg 1980;62-A*:696-705.

32. Noyes FR, Butler DL, Grood ES, Zernicke RF, Hefzy MS. Biomechanical analysis of human ligament grafts used in knee-ligament repairs and reconstructions. *J Bone Joint Surg (Am) 1984;66*:344–352.

33. O'Brien SS, Warren RF, Pavlon L. Reconstruction of the chemically insufficient ACL with central third of patella ligament. *J Bone Joint Surg 1991;73-A:*140-51.

34. Paessler HH, Mastrokalos DS. Anterior cruciate ligament reconstruction using semitendinosus and gracilis tendons, bone patellar tendon, or quadriceps tendon-graft with press-fit fixation without hardware. A new and innovative procedure: *Orthop Clin North Am 2003;34(1)*:49-64.

35. Papageorgiou CD, Ma CB, Abramowitch SD, Clineff TD, Woo SL. A multidisciplinary study of the healing of an intraarticular anterior cruciate ligament graft in a goat model. *Am J Sports Med 2001;29*:620– 626.

36. Scranton PE, Lanzer WL, Ferguson MS, Kirkman TR, Pflaster DS. Mechanisms of anterior cruciate ligament neovascularization and ligamentization. *Arthroscopy 1998;14*:702–716.

37. Shelbourne KD, Gray T. Anterior cruciate ligament reconstruction with autogenous patellar tendon graft followed by accelerated rehabilitation. *Am J Sports Med 1997;25*:786–795.

38. Simonian PT, Erickson MS, Larson RV, O'Kane JW. Tunnel expansion after hamstring anterior cruciate ligament reconstruction with 1-incision endobutton femoral fixation. *Arthroscopy 2000*;16:707– 714.

39. Souryal, T. & Freeman, T. (1993). Intercondylar notch size and anterior cruciate ligament injuries in athletes: a prospective study. *American Journal of Sports Medicine, 21*,535-539.

40. Souryal, T., Moore, H., & Evans, P. (1988). Bilaterality in anterior cruciate ligament injuries: associated intercondylar notch stenosis. *American Journal of Sports Medicine, 16,* 449-454.

41. Staubli HU, Schatzmann L, Brunner P, Rincon L, Nolte LP. *Quadriceps tendon and patellar ligament: cryosectional anatomy and structural properties in young adults*. Knee Surg Sports Traumatol Arthrosc 1996;4:100–110.

42. Tomita F, Yasuda K, Mikami S, Sakai T, Yamazaki S, Tohyama H. Comparisons of intraosseous graft healing between the doubled flexor tendon graft and the bone–patellar tendon–bone graft in anterior cruciate ligament reconstruction. *Arthroscopy 2001;17*:461–476.

43. Turek SL. Orthopedics. *Principles and their Applications.* 4th ed. Lippincott - Raven publishers. 1984;1290-92.

44. Walton M. Absorbable and metal interference screws: comparison of graft security during healing. *Arthroscopy 1999:15*:818–826.

45. Woo SL, Hollis JM, Adams DJ, Lyon RM, Takai S. Tensile properties of the human femur-anterior cruciate ligament–tibia complex. *Am J Sports Med 1991*;29:217–225.