Reconstruction of the Knee Joint

S. Niwa · S. Yoshino · M. Kurosaka
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With 207 Figures

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Preface

More than 20 years have passed since the International Symposium on Total Knee Replacement was held in London in 1974. Prosthetic design and operative technique have been greatly improved since then, and there is now an accepted standard concept of total knee arthroplasty.

Thirteen years after the London symposium, another international symposium on total knee replacement was held, this time in Nagoya, Japan, in 1987. Its ambitious objective was to push forward the frontiers of continuous investigation and improvement of total knee replacement. The fruits of the individual efforts presented at the Nagoya symposium were published in a volume of proceedings entitled *Total Knee Replacement*.

In the years since 1987, further investigations have been conducted in various parts of the world regarding prosthetic design, fixation, long-term radiological follow-up, biomechanical evaluation, and biomaterials research. In knee ligament reconstruction, rapid progress has been made in the past five years in clinical practice and fundamental research by means of arthroscopic surgery and tissue transplantation, and we have come close to establishing a standard treatment.

Under these circumstances, an international symposium on knee joint reconstruction was planned for 1994, again to be held in Nagoya, to provide ample opportunity for exchanging information and sharing clinical experience from around the world. The symposium concluded successfully as numbers of contributors from different countries presented their clinical experience and expertise in knee joint reconstruction to a large audience, with lively discussions of present and future problems. Most of the papers that were presented, as well as the discussions that followed, have been collected in this proceedings titled *Reconstruction of the Knee Joint*. Several papers were not ready in time for publication, but their key ideas can be found in the discussion sections.

We hope that this book will be beneficial to all orthopedic surgeons performing knee reconstruction surgery and to those scientists and bioengineers engaged in research related to the knee joint.

Shigeo Niwa
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Masahiro Kurosaka
Konsei Shino
Sumiki Yamamoto

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Basics

Healing of Knee Ligaments

Cyril B. Frank

Abstract. Animal models of knee ligament injury have shown that collateral ligaments heal very slowly (during a period of months to years) by scar tissue formation. Gross, histological, biochemical, and biomechanical evaluations all suggest that this scar tissue is, in some ways, similar to normal ligament tissue; however, in many ways it is not. Even after many months there are persistent structural, material, and organizational abnormalities in scars (relative to the normal ligament) that appear to be permanent in these models. Scars reach only about 30% of the ultimate failure stress of normal ligaments after 78 weeks of healing, for reasons that are still being elucidated. Possible reasons for scar weakness include the presence of many types of organizational "defects" in the scar matrix, collagen microfibrils that are smaller than normal, abnormal proportions of collagen types, the failure of collagen cross links to mature normally, and the long-lasting presence of abnormal proteoglycans in scars. In addition to high-load abnormalities, scars also show some persisting low-load changes. Their viscoelastic behaviors remain slightly altered for months to years.

There are some clinically relevant variables that do influence the high-load behavior of scars in animal models. The proximity of torn ligament ends, for example, makes a difference in the rabbit medial collateral ligament (MCL). A large gap between torn ends that fills with scar tissue renders the scar only about 50%–60% as strong as a ligament complex which heals with torn ends touching. A second clinically relevant variable that influences healing is joint motion. Immobilization inhibits ligament scar formation and scar mass, thus making a scar structurally weaker. Movement encourages scar mass to build, thus making it stronger. The optimal amount of movement to promote mass without causing other secondary problems has yet to be defined.

Cruciate ligaments have a poorer functional healing potential than collateral ligaments, partly because of their relative failure to produce scar plus their lack of supporting structures on which to build a scar lattice in the joint. Cruciate healing potential is otherwise largely unknown. Much work remains to be done for us to understand and optimize the processes of ligament healing for all knee ligaments.

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Natural History of Anterior Cruciate Ligament Injuries

Robert J. Johnson

Abstract. The natural history of the anterior cruciate ligament- (ACL-) deficient knee is unknown. We cannot predict the course of a patient with an ACL-deficient knee immediately following the initial injury. There can be no doubt that some patients function at a high level with little or no difficulty, while others are troubled severely by functional instability requiring marked changes in their lifestyles.

Why do we not have a better understanding of this common problem? The reasons are numerous: (1) the diagnosis is often missed; (2) only symptomatic patients present for treatment after ACL disruption; and (3) until recently the function of the ACL was considered controversial. It has been taught by many of the "great authorities" that the ACL was unnecessary, and this confused many physicians. Also, (4) ACL tears are rarely isolated, thus the disability produced by a combination of ligament and meniscal tears makes it difficult to be certain which problems can be blamed on the ACL tear and which on the other lesion; (5) investigators assign varying degrees of significance to dysfunction observed after ACL tears; and (6) there are no long-term follow-up studies (10 years or more) showing the eventual outcome of ACL injuries treated without repair or reconstruction and few long-term studies of various repair procedures. The "natural history of ACL surgery" is also unknown.

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Healing Can Be Expected for Acute Anterior Cruciate Ligament Injury

H. Kurosawa, A. Kawakami, M. Oshida, and I. Onishi

Abstract. It has been believed that acute anterior cruciate ligament (ACL) injury does not heal conservatively. We have performed conservative treatment with minimal surgery under arthroscopy for selected patients with acute ACL injury. The patients were followed up, and the results are presented here.

Since October 1990, we have treated patients by the following method. This method was indicated primarily for acute ACL patients whose activity level was relatively low. Twenty-two of 25 patients who were 1 year 9 months or more past treatment were followed up; the average term was 2 years 7 months. In all patients, rupture of ACL bundles was confirmed; the torn bundles were then repositioned and reattached to the femoral attachment with fibrin arthroscopically. After treatment, the knee was immobilized with LMB for 3 weeks, and movement was resumed gradually.

In 2 patients, the ACL was reruptured during sports activities after treatment. Of 22 patients followed up, 16 patients did not experience giving way of the knee, but 6 patients did. Pivot shift was negative in 11, grade 1-positive in 5, and grade 2-positive in 4 patients. KT-1000 measurement under 20 lb revealed that the preoperative injured–noninjured difference was 5.7 ± 2.2 mm (range, 2–10 mm) and the postoperative difference was 2.2 ± 1.5 mm (range, −1–6 mm). In 10 patients (50%), the KT-1000 difference was less than 3 mm at follow-up.

Palmer and O'Donoghue reported that acute ACL injury did not heal clinically or experimentally. On the other hand, Hefty revealed that ACL injury could heal without any treatment if some of the bundles were reattached experimentally. From our preliminary clinical study, we concluded that the repair process can be expected when applying conservative treatment with minimal surgery under arthroscopy.

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ACL Reconstruction

Overview of Anterior Cruciate Ligament Reconstruction

Hideshige Moriya

Abstract. Anterior cruciate ligament (ACL) reconstruction is a widely accepted procedure for ACL insufficiency, and many aspects of the procedure are changing. I discuss here the current trends regarding ACL reconstruction. The indication for ACL reconstruction was previously thought to be young athletes, but now even athletes over 40 years of age are included. Conservative treatment or primary repair for ACL injury has been tried by many authors, but their results were not satisfactory.

The only reliable method of treatment is reconstruction, using either biological or synthetic materials. As an autogenous graft for reconstruction of the ACL, bone–patellar tendon–bone, hamstrings, and the ilio-tibial tract (ITT) are utilized. Among these, the bone–patellar tendon–bone graft fixed by Kurosaka screws is the most popular. However, other procedures are indicated when patellofemoral disorders exist. Hamstrings, which are the semitendinosus and gracilis tendons, are also used as first or second choice. The ITT procedure is the easiest way of reconstruction, but the ITT tends to be weak as a substitute. Revised procedures using an ITT that is reinforced by a retinaculum or a gracilis tendon have appeared recently. An allograft using bone–patellar tendon–bone or bone–achilles tendon is one of the choices for ACL reconstruction. Synthetic materials are not as popular as they were previously. In Japan, the Leeds–Keio ligament is very popular, but precise technique is required for successful results.

The isometric point for tibial attachment was thought to be the anteromedial area of the anatomical ACL attachment. Since roof impingement has become a topic of discussion, it was thought to be the center of the anatomical ACL attachment. A femoral tunnel is made in the superoposterior area of the anatomical origin of the ACL. These techniques are performed under arthroscopy. After ACL reconstruction, the rehabilitation program is started as early as possible to prevent muscle weakness and loss of proprioception.

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The Biology of Ligament Reconstruction

Cyril B. Frank

Summary. Despite contemporary enthusiasm for ligament reconstruction procedures, only modest interest is evident in the literature with respect to the biology of ligament grafts. However, the long history of scientific investigation into tendon transplantation (tendons being the soft tissue most closely related to ligaments) contains numerous observations pertinent to the current interest in ligament transplantation. Both topics are reviewed, and encouraging evidence to support the ongoing scientific investigation into both tendon and ligament graft biology is described.

Key words. Ligament—Tendon—Transplant—Biology—Graft

Introduction

The recent increase in clinical enthusiasm for the surgical correction of joint instabilities using ligament reconstruction procedures has caused a concomitant interest in factors or techniques that might improve results. The majority of interest to date has been focused on mechanical factors that might influence graft outcome, such as graft placement, tension, mechanical properties, and the postoperative presence or absence of graft loading. Relatively few investigators have shown an interest in studying the biology of ligament grafts, perhaps because most assume that these tissues are relatively inert or that this information would not make a practical contribution to graft optimization. There is, however, both long-standing and recent information to suggest that these assumptions are not correct.

In this chapter, I summarize what I believe to be the key findings from investigations in areas that are relevant to ligament reconstruction. I provide readers with a reference base from which they can acknowledge with confidence that both ligaments and ligament grafts are living tissues, with a very interesting and complex biology, and further that control over biological factors may be crucial to the goal of graft optimization.

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