Impact Objective

- Developed and patented an original laser-guided drill guide for creating bone holes during arthroscopic ligament reconstruction

Better outcomes for ACL surgery

__Dr Toshiaki Takahashi__ has developed novel methods to make anterior cruciate ligament (ACL) surgeries quicker, more effective and less invasive for patients. His developments in sports medicine will lead to positive outcomes for athletes seeking to continue their career post injury

What is it about key hole surgery that interests you? Can you talk about your background researching this area?

My speciality is orthopaedics and sports medicine. I engage in the treatment of knee disorders in particular. As the surgical procedure of ACL reconstruction – a still invasive operation requiring expert arthroscopic techniques – is currently popular, I thought it necessary to have a simpler and more accurate surgical procedure. Therefore, we developed and improved a minimally invasive, all-inside ACL reconstruction.

Who will ultimately benefit from this research?

Although the anterior cruciate ligament reconstruction technique is often practiced in countries where sports are popular, there are many cases where patients don't fully recover to their pre-injury performance. For this reason, it necessary to improve current methods and I believe it is important to disseminate the techniques we are currently using. Additionally, since our improved endobutton provides good fixation and tightness of the ligament, I would like to spread this information to improve surgical performance.

In developing countries, the number of orthopedic surgeons is relatively small compared to the population ratio, so doctors who can properly perform arthroscopic ACL reconstruction are very limited. Meanwhile, sports fever around the world increases, and in order to perform physical activities, it is often necessary to undergo ACL reconstruction surgery. Therefore, it is very meaningful to provide ACL robotic equipment as technical assistance so that many ACL reconstruction techniques can be performed even in medically under-populated areas and developing countries with only a few specialists.

You have developed and patented a drill guide pin and reamer that supports the use of the all-inside technique. Can you explain what benefits the pin and reamer delivers over other similar tools?

At first, we developed a laser-guided drill for preparing the bone hole by laser beam irradiation, but then we discovered that this drill guide can create a bone hole between the femur and tibia in a straight line. In addition, by using our developed pin and reamer guide, it is possible to create a bone hole at a convenient and accurate position, facilitating the use of the all-inside ACL technique with an intra-articular approach to create bone holes with quick and minimal invasiveness. We have obtained excellent joint stability and clinical post-operative outcomes.

Can you talk a little about using the laser-guided technique in a clinical setting? Have you seen any results you were particularly pleased with?

In the trans-femoral approach, a drill guide for preparing the bone hole is installed in the ACL attachment part of the femur. At that moment, because the laser beam is irradiated on the extended line of the drill guide pin, it is possible to simultaneously determine the ACL attachment portion of the tibia. In other words, by using only one bone hole drill guide, it is possible to determine two bone hole positions. This makes it easy to carry out the all-inside method, which simplifies the operation and minimises invasion in the bone.

What are you planning to study in the next year?

Currently, the surgical technique by manual operation has greatly improved, but as a next step, we are thinking of a robot-assisted method that would lead to remarkably improved and accurate techniques in terms of bone hole location and shortened operation time. We are working on that research now. ●

Improving how we heal our athletes

While our current medical technologies are highly sophisticated and can accomplish many extraordinary outcomes, they are not always perfect. In the field of sports medicine and knee surgery, __Dr Toshiaki Takahashi__ is perfecting our medical knowledge, promising patients improved results

In the world of sports, anterior cruciate ligament tears are far from uncommon. Known as 'tearing your ACL', athletes frequently endure ACL surgeries in the hope of restoring their physical abilities and returning to the game as soon as possible. As common as these injuries are, they are not minor. ACL tears are severe knee ligament injuries preventing people from playing sports, as well as participating in many kinds of strenuous activity.

Not treating these tears leads to extensive complications down the road. These injuries can eventually progress into knee osteoarthritis, requiring total knee replacement in the future. As ACL tears calling for ligament reconstruction increase by the year, specialised hospitals, particularly in urban regions, continue to be the only resources for patients needing this technically challenging arthroscopic procedure. Developing countries, in particular, find it difficult to achieve positive arthroscopic ACL reconstruction outcomes for their patients. During surgery, placing holes correctly within the femur (thigh) and tibia (shin) bones is an extraordinarily challenging task, demanding exceptional expertise, that has the ability to drastically effect patient outcomes.

Dr Toshiaki Takahashi, Professor at Ehime University Faculty of Collaborative Regional Innovation Division, Department of Sports and Health Science, Japan, has developed innovative methods to surmount current issues with typical ACL reconstruction surgeries. These advancements include new fixtures used in the ligament, as well as more accurate, quicker methods for piercing bone, predicting a more promising future for ACL tear sufferers. 'One of the purposes of our project is to perform minimally invasive ACL reconstruction safely and accurately as much as possible without expert skill and techniques,' explains Takahashi.

REFINING SURGERY

Current procedures used in ACL reconstruction involve either a single- or double-bundle technique. The ACL is made of two bundles of fibrous tissue; though, because of their close proximity, it can be difficult to distinguish between the two. 'Single-bundle ACL reconstruction uses one tendon graft in lieu of the ligament, while the double-bundle technique uses two in an effort to more accurately represent the original tissue, requiring more bone holes to achieve results,' points out Takahashi. Both techniques have become common procedures and, in general, have beneficial clinical outcomes.

However, new studies are continually reporting support for double-bundle ACL reconstruction as it purportedly restores the rotational ability of the knee better than single-bundle ACL reconstruction. Yet, despite these results, double-bundle ACL reconstruction in its current form is not perfect, and both single- and double-bundle techniques can cause the bone tunnels created during surgery to widen after the operation in a way that is uncomfortable or undesirable for patients due to movement of the graft within the created holes. This complication can lead to reduced joint stability and athletic performance. Additionally, if the reconstruction is poorly carried out, cartilage deterioration can lead to osteoarthritis. With these negative outcomes, additional surgeries can be carried out to attempt and aid these patients with knee instability and constant pain.

Takahashi and his colleagues have been working on a remedy to these common complications by adjusting surgical procedures to generate more accurately placed, anatomically appropriate bone holes. 'In establishing an all-inside double-bundle ACL reconstruction technique, we have already seen improvements in patient-reported outcomes for manoeuvring the knee and knee stability,' he says.

LASER TECHNOLOGY

To perform their all-inside double-bundle ACL reconstruction technique, Takahashi and his colleagues created a laser-guided drill guide to immensely enhance the accuracy of bone hole placement, identifying the ideal placement for graft attachment during ligament reconstruction. One positive ▶

By performing this surgical technique, many ACL patients can acquire normal knee function and perform sports and physical activity throughout their lifetime

aspect of the laser-guide is its ability to mark the target locations for holes on the femur and tibia at the same time, allowing for perfectly parallel bone hole creation,' he explains. Also referred to as the laser-assisted tibial drill guide technique or the transtibial method, the team's innovation has obtained excellent clinical results thus far. 'The technique has reduced operative time and surgical morbidity and is more technically accessible and less demanding.'

In addition to their laser-guide, Takahashi's version of double-bundle ACL reconstruction makes use of their newly developed, patented pin and reamer. This tool allows an all-inside technique, creating bone holes quickly and with minimal invasiveness. Clinical studies using this new device have proved highly successful, increasing accuracy of bone hole placement and generating greater knee stability for patients post-operatively.

The team's results have been exceptional. With the transtibial double-bundle ACL reconstruction using the laser-assisted tibial drill guided technique and their particular pin and reamer, knee pain after surgery decreased, knee stability increased and athletes were able to return to their sport sooner than with conventional techniques. 'By performing this surgical technique, many ACL patients can acquire normal knee function and perform sports and physical activity throughout their lifetime,' adds Takahashi. Preparing to present and publish their findings, Takahashi and his colleagues are sure to make a far-reaching contribution to the field of sports medicine.

INNOVATIONS AHEAD

Thus far, Takahashi and his team have developed many successful technologies that have proved helpful to patients. In addition to the laser-guide for ACL reconstruction and the pin and reamer for ligament placement, they also developed an improved endobutton. Commonly used in knee surgery, these small elliptically shaped devices are used for ligament fixation. The team's improved endobutton fixes ligaments more securely than typical models and allows for an appropriate amount of tension. They are currently in the process of placing their new design on the market.

Using these innovative technologies, the team is working towards minimally invasive ACL reconstruction with better patient outcomes. In addition to preparing to distribute their products in an all-inside, minimally invasive ligament reconstruction kit, Takahashi and his colleagues are working to introduce robotic technology in the creation of bone holes. This new technology would continue to shorten surgery time and further improve accuracy of location placement.

The main goal of Takahashi's team is to improve outcomes of suffering patients. Therefore, it is of the upmost importance to them to make their technology accessible to doctors of varying abilities, so that patients need not seek treatment in only certain, specialised hospitals. Takahashi's work proves promising to ACL tear patients around the globe as his team makes successful surgery attainable despite a surgeon's expertise. 'We should always keep in mind that we have to contribute to the society, including rural areas and emerging countries, to truly solve these medical issues,' states Takahashi. ●

Project Insights

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ACADEMIC COLLABORATORS

Professor Manabu Takahashi and Associate Professor Tomonori Yamamoto – Faculty of Collaborative Regional Innovation Division, Ehime University, Japan • Assistant Professor Seiji Watanabe – Department of Orthopaedic Surgery, Graduate School of Medicine, Ehime University, Japan

INDUSTRY COLLABORATORS

Tanaka Medical Instruments Co., Ltd, Tokyo, Japan • Tanaka Giken Co., Ltd, Ehime, Japan

CONTACT

Professor Toshiaki Takahashi
Project Coordinator

T: +81 89 927 8927
E: takahast@m.ehime-u.ac.jp
W: www.cri.ehime-u.ac.jp/teacher/

PROJECT COORDINATOR BIO

Professor Toshiaki Takahashi graduated from the Faculty of Medicine, Kochi Medical School, Japan, with his PhD in 1997. He has completed a fellowship with the American Academy of Orthopaedic Surgeon (AAOS) and American Orthopaedic Association (AOA), Educational Exchange Program and as a Research Fellow of Harvard University, Massachusetts General Hospital, Boston, US. He is now a Professor at the Ehime University, Faculty of Collaborative Regional Innovation Division, Department of Sports and Health Science. Takahashi is a member of a number of academic societies including the Japanese Orthopaedic Association, International Society of Arthroscopy, Knee Surgery & Orthopaedic Sports Medicine and the Japanese Society of Clinical Sports Medicine. He is also an editorial board member of *Journal of Orthopedic Science*. His major research interests are arthroscopy, sports medicine and adult knee reconstruction.

株式会社 田中医科器械製作所
Tanaka Medical Instruments Co., Ltd.

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