MEDICAL PRACTICE

# Minimally invasive surgery in orthopaedics. Small is beautiful?

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**With the blooming of minimally invasive procedures in surgical specialties, many orthopaedic subspecialties have been evolving along such lines. Despite the apparent paradox that many orthopaedic implants are quite bulky to start off with, different methods have been adopted to insert them safely with the least possible trauma. Altering time-honoured incisons and surgical techniques has often been helpful. The industry is also very keen to re-design implants for this purpose and has contributed substantial momentum in this direction. Coupled with the use of operating microscopes, endoscopes, and imaging modalities, operations can be performed with greater precision and lesser trauma. The advent of computer-assisted technology is another step forward. It is through constant attention to minimising tissue trauma and a combination of different methods available, that surgeons can achieve the ultimate goals of minimally invasive surgery.**

## Introduction

Wounds heal from their sides and not their ends. Hence, as advocated in Arnold Henry's anatomy classic '*Extensile exposure*',[1] it is a common belief that surgical exposure should be as extensile as the tongue of the chameleon, to reach wherever it is required. In recent years, there has been a tremendous boom in minimally invasive techniques in practically all surgical specialties and subspecialties. In many instances, surgeons are able to accomplish their tasks not only through smaller wounds but also with less tissue trauma, blood loss, and resort to analgesics. The benefits to patients and society are obvious, when suffering is reduced and a quicker return to usual activities is possible. In this pursuit however, every effort must be taken to ensure that the quality of outcomes and patient safety are not compromised.

In this issue, there are two papers on orthopaedic topics—Achilles tendon rupture[2] and problems related to repetitive occupational strains.[3] Minimally invasive techniques are applicable to both repair of the Achilles tendon, and more commonly, for carpal tunnel release. Even within the confines of orthopaedic surgery, there are so many developments in minimally invasive techniques that it is not possible to list them exhaustively. However, they share several common features. The underlying drive in this direction is the desire to achieve the same or superior surgical results, but with less trauma than conventional approaches.

## Incision

A more strategically placed incision can sometimes reduce the length required, even for inserting implants of considerable size (such as for total replacement of hips and knees). One commonly embraced concept is to change the conventional practice of making a long incision that enables clear visualisation of the entire operative field at one glance, whereby the surgeon can easily appreciate the spatial relationship of different anatomical parts. However, it is possible to retract a smaller wound along a specific direction in order to visualise only the part of the wound being operated on and change the direction when the focus of attention is changed to another part. In short, the wound becomes a small mobile window through which different anatomical parts can be reached with the symbiotic use of the appropriate retractors.

In total hip replacement, it requires no rocket science to perceive that the minimal incision required to insert a hemispherical socket must be half of its circumference and is therefore 3.14 times its radius. To this end, several methods have been described and minimal incisions have been classified into two categories: (1) those using either the anterior, anterolateral, and posterior routes, and (2) those using two incisions.

Taking the minimal anterolateral approach as an example, an oblique incision centred at the greater trochanter is used. The caudal part of the incision is along the direction

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## 骨科微創手術：以小為佳？

不少骨科的附屬專科一直以來也正如其他外科專科技術一樣，朝著微創的路向蓬勃發展。矯形植入物的體積往往相當大，處理不易，微創看來不切實際，儘管如此，骨科仍採用了不同的方法，以便手術在外傷最少的情況下安全進行。改變沿用已久的切口及外科技巧，往往有幫助。業界也十分積極為此而重新設計植入物，並且努力推動這方面的發展。骨科手術利用手術顯微鏡、內窺鏡，以及各種造影模式，可提高準確度，並減少外傷。而在引入了電腦輔助技術後，骨科手術更跨前了一步。把手術引發的傷害減至最少是外科醫生的職志，加上種種方法的結合使用，微創手術的最終目標應指日可待。

of the reamer for the anteverted acetabulum while the cranial part is along the reamer to prepare the femoral medullary canal. This slight modification permits surgeons to continue using an approach that they are familiar with and yet reduces the incision to less than 10 cm. This method has also been reported by local surgeons.[4]

The two-incision approach was described by Berger.[5] Removal of the femoral head through the anterior incision is facilitated by removing a segment of the neck first. Preparation of the femoral side was through a small posterior incision between the posterior border of the gluteus medius and piriformis. Fluoroscopy is required for this method.

Unicondylar knee replacements (UKRs) are smaller in size and there is greater potential to insert them through smaller wounds than total knee replacements (TKRs). However, the results achieved with early models of the UKR in the 1970s and 1980s were so inferior to TKR that in the early 1990s, UKR was largely abandoned. With improvements in design and technique, the reported results improved to yield over 90% 10 years' survival.[6] It was around this time that the minimally invasive technique for UKR was described[7] and subsequently extended to TKR.[8]

## Surgical technique

The development of intramedullary fixation of long bone fractures enables very stable fixation through small incisions at one end of the bone. This has become the standard practice for most femoral and tibial shaft fractures, both locally and abroad. It is also applicable to fractures of smaller bones, such as at the neck of the metacarpal (described by Foucher,[9] using a bouquet of K-wires inserted through a small incision at the base of the metacarpal). Local hand surgeons have also reported good results with this method.[10]

In the late 1990s, techniques were described for fixing fractures around the hips and knees by inserting implants percutaneously through small incisions.[11,12] This concept of minimally invasive percutaneous plate osteosynthesis is also applicable to other fractures.

## Special implants

In the fixation of long bone fractures, the conventional approach was to expose the long bone concerned and bend a plate to fit the contour of the bone before fixation with screws. With the development of Less Invasive Stabilization Systems, plates specifically pre-shaped to different parts of bones are available to facilitate percutaneous plate insertion to the fracture site. An entirely different principle is employed for the screws. By using locking screws that provide angular stability at the screw-plate junction, the whole construct becomes an internal fixator. With this, the plate no longer requires to be compressed against bone in order to achieve stability. On the contrary, a gap between the plate and bone is highly desirable, so that the blood vessels along the periosteum are not compressed and sound biological fixation can be established.[13]

For total joint replacement, the size of the implant is an obvious limiting factor. With some designs, it is possible to separate the tibial component into two parts, enabling the tibial base plate and the keel to be inserted separately and assembled inside the wound. Thereby, the size of the wound is minimised.

## Operating microscope

The publication of Mixter and Barr in 1934[14] provided convincing evidence that sciatica was related to herniated lumbar discs. For several decades, the prevailing approach to treatment was to remove the disc material through a laminectomy. Over the years the importance of preserving the lamina and the facet joint was realised and it was possible to achieve through a small fenestration at the appropriate laminae. In the mid 1960s, Yasargil pioneered use of the operating microscope and microsurgical techniques for spinal surgery,[15] and the results of lumbar microdiscectomy were eventually published in 1977.[16] In the following year, Williams[17] reported his results on 532 patients, most of whom were Las Vegas showgirls. Then microsurgical techniques were extended to decompression of spinal stenosis. In the 1990s, McCulloch[18] reported on central and foraminal decompression through an ipsilateral laminectomy using the microscope.

## Endoscopes

Only in the past few decades have endoscopes changed from using light bulbs inside joints to rod lens systems and fibre-optic cables. Previously the surgeon had to bend down and strain his eye

through the eyepiece and only the surgeon could see what was happening. With the development of a camera attached to the endoscope, the entire team can witness the whole procedure in a comfortable position. The impact on knee surgery was particularly significant. In the old days, open total meniscectomy was preferred,[19] but is now being replaced by arthroscopic partial meniscectomy or meniscal repairs for peripheral tears. The medical equipment industry has responded efficiently to this revolution. Numerous pieces of equipment have been designed to facilitate the passing, tying, and anchoring of sutures through the arthroscope. Moreover, it is possible to pass sutures from the inside to the outside of the joint and vice versa, or the entire procedure can be performed inside (using the arthroscope). Another very common arthroscopic operation for the knee is reconstruction of cruciate ligaments. Minimally invasive procedures are particularly attractive for this group of patients who are usually young and active. It is in the mutual interest of these patients and society to expedite their rehabilitation.

For recurrent dislocation of the shoulder, open repair had a success rate of 96.5%.[20] In the early days, the short-term results of arthroscopic repair were good,[21] but increasing re-dislocations were encountered in the long term.[22] In 2000, Cole et al[23] reported equally good results with open and arthroscopic repair, though there were more complicated cases in the former group. Shoulder arthroscopy is also frequently employed for the treatment of impingement syndromes and rotator cuff lesions.[24]

Different methods of endoscopic carpal tunnel release have been described, using either a single portal at the wrist or with an additional portal at the palm. Both methods are being used locally.[25,26] Local surgeons have also reported using arthroscopic treatment of volar wrist ganglia and tears of the triangular fibrocartilage complex.[27,28]

Returning to spinal surgery, Obenchain[29] reported the first laparoscopic discectomy of the L5/S1 disc in 1991. Yeung and Tsou[30] published their results of posterolateral lumbar discectomy using fluoroscopy and endoscopy in 2002. Local work in this field has also been reported.[31] In 1997, Foley and Smith[32] published the use of tubular dilators and retractors to achieve discectomy, in conjunction with microendoscopic techniques. The concept of using "tubeology" was extended to other spinal surgeries. In 2007, Asgarzadie and Khoo[33] reported its use in 48 patients with spinal stenosis. Using microendoscopic decompressive laminotomy, 88% of patients enjoyed improvement in symptoms beyond 4 years. Beisse[34] reported anterior decompression and internal fixation of thoracolumbar spine fractures via thoracoscopy.

The foot is also within the reach of arthroscopes. Thus, arthroscopes have been used as an aid to correct or tackle hallux valgus, triple arthrodesis, arthrodesis of the Lisfranc joints, Freiberg's disease, pathologies of the tendo-Achilles and ganglion of the foot. These arthroscopic applications have also been reported by local surgeons.[35]

## Imaging

Many procedures can be performed with greater accuracy and safety with the guidance of ultrasound, X-ray, or computed tomographic (CT) scanning. Intralesional injection of steroid for subacromial impingement, and aspiration of deep-seated abscesses (eg in the iliopsoas) can be performed with precision. For tumours of soft tissues or bone, if a definitive diagnosis can be achieved through a needle biopsy, the patient need not undergo an additional operation for open biopsy and it becomes easier to include the needle track when the tumour is ultimately excised.

In the operating room, intra-operative fluoroscopy becomes a basic necessity rather than a luxury. Close reduction and percutaneous fixation are possible for some fractures, and local surgeons have been very active in applying this technique for the management of scaphoid fractures.[36,37]

Percutaneous vertebroplasty was developed in France and published by Galibert et al in 1987.[38] This technique was developed to augment management of osteoporotic compression fractures of the spine by injection of bone cement (using a transpedicular or extrapedicular approach). This was followed by kyphoplasty, which involved the insertion of an inflatable balloon into the vertebral body to elevate the vertebral end plate, so as to correct the kyphosis before cement injection. This enabled a more controlled injection into the cavity with less risk of cement extrusion.[39]

With the assistance of imaging, radiofrequency ablation can be used to treat certain benign bone tumours such as osteoid osteoma,[40,41] and also as a palliative treatment for metastatic malignant deposits in bones. Imaging can be extended to the treatment of unresectable tumours by combining ablation with percutaneous cement injection.[42]

## Computer navigation

The computer can be used to locate the position of anatomical parts and instruments, if dynamic reference arrays are firmly attached to them. Through the process of paired-point matching, the locations of specific anatomical parts are then registered on the computer to match the corresponding points of the image obtained either from preoperative CT scans or intra-operative fluoroscopy. Isocentric C-arm fluoroscopy and O-arm CT-fluoroscopy are

recent developments that are more user-friendly to surgeons. Computer navigation enables surgeons to plan, execute, and assess the results of surgery intra-operatively. This is especially valuable in minimally access surgery, where the surgeon often cannot utilise the spatial relationship between different anatomical parts to determine the surgical anatomy. This may occur because only a small part of the body can be seen at one time. In which case, computer navigation can reduce irradiation associated with intra-operative fluoroscopy, and generate images in multiple planes simultaneously and in real time. In spinal surgery, this is being used for placement of pedicle screws, C1/2 transarticular screws, lateral mass fixation, percutaneous internal fixation, and the management of spinal decompression.[43] For joint reconstruction, it is used for osteotomy correction of angular deformity of the knee,[44] total hip replacement,[45] and TKR.[46]

Of the many techniques mentioned above, some may eventually evolve into indispensable tools, while others will fade away. The determining factors rest in the ability to minimise tissue trauma, the quality of results achievable, and the risks involved. The length of the scar, though the easiest to measure at the front end, is the least important of these many factors.

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