Minimal Invasive Orthopaedic Surgery

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In the old days, all surgeons were taught the value of a wide exposure in their surgery. The main advantages of wider exposure include; better direct visualization, better direct access to the pathology, sufficient room for surgical maneuvers. However this conventional wider exposure may create several disadvantages including; greater soft-tissue dissection with may compromise blood supply to the lesion such as bony fractures, greater intra- and post-operative blood loss, greater post-operative pain, longer hospitalization and wider area of scarring with negative cosmetic impact or rehabilitation difficulties. During the past three decades there has been a move towards smaller exposure in a variety of surgical disciplines and the term of minimal invasive surgery (MIS) has been proposed. The MIS has been developed along with the advancement of the new technology that can be effectively used with limited or tiny incision. Visualization of the bone lesion can be obtained by modern imaging technology instead of direct visualization. Access to the lesion can also be performed by modern small instrument such as arthroscopic or endoscopic instruments. With modern advance technology, the operation can be performed with smaller or shorter incision or can be performed percutaneously at the area of lesion or at a distance from the lesion. This method can lessen soft tissue dissection, minimize blood loss, lessen post-operative pain and faster recovery and shorten the hospital stay.[1]

Orthopaedic surgeons have been among the leaders in research and development of the minimally invasive techniques. In fact, there have been certain techniques in orthopaedic surgery being used for more than half century that may be considered as a minimally invasive surgery. These include; percutaneous fixation by pins or wire for periarticular fractures, epiphyseal fractures in children and closed intramedullay nailing for long bone fractures such as femur and tibia.[2-4] The evolution of the minimally invasive method in orthopaedic surgery has been progressed along with the advancement of the new technology that can help surgeon to perform the operation precisely without opening the bony lesions or with limited exposure of the operating field. The important technologies that facilitate the minimally invasive orthopaedic surgery include; the image system, the arthroscopic equipment and the computer assisted system or the navigation system.[5-7]

The image-assisted surgery

With the advancement of the image technology, the bony fracture can be visualized for its configuration and alignment. At the early development, the head worn fluoroscope was used by the surgeon during closed manipulation of fractures or dislocations.[3] The method can also help facilitate for fracture fixation without opening the fracture site. However this type of fluoroscopic technique lenders the surgeon to exposure to the direct x-ray beam and will expose to large amount of the radiation. This made the procedure non-popularize for most surgeons at that time and internal fixation of the fracture by direct open reduction at the fracture site was more preferable. It was until 1967 that the development of the image intensification became generally available.[3] The image intensification can provide better visualization of the bone alignment during surgery with less radiation exposure to the patient, the surgeon and the operating personnel. This lessened the risk of radiation exposure and permitted a return of favorable technique of closed reduction and internal fixation of the fractures such as closed intramedullary nailing of long bone fractures, percutaneous fixation by pins or wires of small bones.[8] The image intensification or fluoroscopy has been further developed for better model and better function. The current model also has better function and greater mobility of the C-arm to change the position and direction of fluoroscopy. The new model can provide better resolution of the image, with higher capacity to restore and replay the image. This makes the current image-assisted surgery to be a widely used in current common orthopaedic practice with minimal radiation dosage.[9,10] The procedure needs very minimal surgical exposure at the area close to the bony lesion as a percutaneous method or from a distance away from the bony lesion as in closed intramedullary fixation method. The method can minimize the disturbance of the soft-tissue attachment around the fracture zone which will better retain the inherent stability and the root of blood supply for fracture healing than the open method. This image-assisted surgery can be categorized as a minimal invasive surgery, has expanded widely in many orthopaedic specialties such as;

- Paediatric orthopaedics: closed reduction of fractures and casting, percutaneous fracture fixation, percutaneous epiphysiodesis, etc.
- Orthopaedic trauma: closed intramedulary nailing of long bone fractures, percutaneous fracture fixations with pin, wire or screw of small bones, percutaneous plate osteosyntheses of periarticular fractures, external fixation, post-traumatic reconstruction, etc.
- Spinal surgery: spinal instrumentation, vertebroplasty, etc.
- Bone tumor: percutaneous bone biopsy, prophylactic fixation of impending pathologic fractures, etc.

Arthroscopic surgery

The method of using arthroscope to visualize the internal derangement within the joint is one of the advancement in minimal invasive orthopaedic surgery. The early development of a rod lens system surrounded by light conducting glass fibrils and enclosed in a rigid metal sheath led to the modern arthroscope.[6] It soon became apparent that this versatile instrument had numerous applications. The instrument was initially used for diagnostic purposes and subsequently the instrumentation was developed to allow treatment of pathology as well. The arthroscopic operations had become established in late 1970s.[11] Early operations were mainly performed on the knee joint which is mobile and easily accessible. During 1970s and 1980s knee surgery became an outpatient procedure performed through a few small incisions around the joint.[11,12] The operation can be performed with minimal damage to the surrounding large muscles and ligaments and can minimize substantial morbidity. With the development of arthroscopic surgery immediate and long-term morbidities were dramatically reduced and better examination of the pathological lesion within the knee joint with less invasive method became possible.

Minimally invasive arthroscopic procedures are now widely used to diagnose and treat diseases and injuries to bones, cartilage, ligaments, muscles and tendons in the hip, knee, ankle, shoulder, elbow or wrist. Arthroscopy can be used for a wide range of purposes, such as repair of torn ligaments or cartilage, removal of loose bone or cartilage as well as treatment of some problems associated with arthritis. With tiny incisions, pain from arthroscopy is minimal and the patient can resume daily activities within a few days. This type of surgery can reduce the hospital stay of the patients, with shortened recovery periods.

Computer-assisted surgery

Computer assisted surgery or computer-aid surgery (CAS) was used firstly in neurosurgery in the late 1980s.[13] The CAS makes use of stored patient-specific imaging data to provide guidance during surgical procedures. This process is synonymous with surgical navigation.[14] The method has been expanded to orthopaedic surgery in 1990s and has been termed as computer assisted orthopaedic surgery (CAOS). The CAOS can provide access to either a three-dimensional data set (3D-CT guidance) or multiple simultaneously-displayed stored fluoroscopic image (virtual fluoroscopy, fluoroscopic navigation).[15] Most of the current systems use an optical tracking system to follow both the position of the target part of the patient and special instruments during the operative procedure.

The 3D-CT system has been available for spinal sugery in early 1990s and was adapted for pelvic and acetabular fracture fixation in 1997. The CAOS has further expanded to be used in total joint arthroplasty and become a part of the development of one type of minimal invasive total joint arthroplasty using the navigation system. Although the 3D-CT guidance remains a powerful tool, the applications of this kind of technology for fracture surgery may be useful for pelvic or acetabular fracture cases. This is because a three dimensional model had to be built using CT data obtained prior to surgical fracture reduction. The model could not be easily updated to provide guidance for fixation following fracture reduction. In general, fractures could be stabilized using 3D-CT guidance only if they were minimal displaced, or if a closed reduction could be obtained and maintained with an external fixator prior to obtaining the pre-operative CT scan. It was in 1999, virtual fluoroscopy has been developed. The images could be harvested and stored in multiple planes during and after reduction or implant placement. This development has been applied to long bone fracture management, and no longer limited to spine and pelvic applications.[14-16]

CONCLUSION

Minimal invasive surgery (MIS) is now one of the most current interesting issues among orthopaedic surgeons. Several orthopaedic operations using MIS have already been proved for their advantages over the conventional methods. However many new development techniques are waiting for the verification of the advantages for the long term advantages especially the MIS technique for total knee and total hip replacements. Cost effectiveness for the procedure is also a point of consideration especially when the procedure requires expensive equipment such as computer assisted surgery. All these aspects are still await for further evaluations.

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