Technical note

Idea and innovation

Simple minimally invasive plate osteosynthesis (MIPO) instruments

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1. Introduction

Minimally invasive plate osteosynthesis (MIPO) has become widely accepted for treatment of periarticular fractures, metaphyseal fractures, or certain diaphyseal fractures where intramedullary nailing is not indicated.1,2,5–8 With this technique, the fracture is reduced by indirect reduction, then an implant is introduced by an incision away from the fracture site or percutaneously and passes the fracture site without exposing the fracture. Since the fractures are not opened, sometimes malreduction occurs. To facilitate percutaneous insertion of implants, fracture reduction and fracture fixation, specially designed instruments are often required.4

MIPO instruments were developed to facilitate surgical techniques and solve intraoperative difficulties. Some of these instruments are commercially available; others are fabricated according to the needs of the surgeon. We present six locally fabricated MIPO instruments from reused hardware called tunneler, percutaneous sleeves for screw insertion, joystick T-handle, wire passer, plate distractor, and tibial alignment grid that will be refined to make the procedure easier, cheaper and more reproducible in the hands of most surgeons.

2. Instruments to aid plate insertion and fixation

2.1. Tunneler (Fig. 1a and b)

2.1.1. Principle

The tunneler is used to prepare a pathway for introduction of the plate through a submuscular or subcutaneous tunnel. It consists of a handle and a blade. The removed narrow or broad DCP is adapted to be used as a blade with the size equal to the plate. The plate is attached to the handle at an angle of 90°. The end of the plate is made thinner and rounded to reduce friction during tunnelling and also to reduce the degree of soft tissue injury during the passing of the tunneler. The narrow tunneler is used for humeral and tibial fractures while the broad tunneler is used for femoral fractures. The broad tunneler has a hole in the middle of the handle to connect with a rod for controlling the direction of the tunneler in different planes. The last hole at the tip of the tunneler will allow a suture to be tied to the end of the plate so that while withdrawing the tunneler, the plate will be pulled into the tunnel.

2.1.2. Surgical technique

Skin incisions are made, corresponding in position to both ends of the plate. All subcutaneous tissue and muscle are dissected deep to the bone without stripping the periosteum. The tunneler is then inserted beneath muscle (Fig. 2a and b) or the subcutaneous plane (Fig. 3a and b) over the periosteum. The tip of the tunneler should touch the bone and be lifted up slightly during advancement of the tunneler to avoid stripping of the periosteum. It is important to avoid introducing it repeatedly or pushing it back and forth too many times, as this will strip the periosteum and further damage the soft tissue.

2.2. Percutaneous sleeves for screw insertion (Fig. 4)

2.2.1. Principle

Conventional sleeves for drilling and tapping are usually too short for percutaneous screw fixation of the femur. Tying a suture to the screw head during screw insertion will prevent losing the screw inside the muscle. For percutaneous screw insertion, a set of trocars with an outer sleeve, a drilling sleeve and a tapping sleeve are always used together. With these stacked sleeves, after finding a hole percutaneously, drilling, tapping and inserting of the screw...
can be done simultaneously without removing the sleeves. These consist of the ball tip trocar, the outer sleeve with two teeth, the inner 3.2 mm sleeve for the drill bit, and the inner 4.5 mm sleeve for tapping.

2.2.2. Technique

After the stab incision is made, the ball tip trocar with the outer sleeve with two teeth at the end is passed through the muscle to find the plate hole. Once the plate hole is found, the outer sleeve is fixed to the plate with the teeth. The trocar is then removed (Fig. 5a). The inner 3.2 mm drill sleeve is inserted into the outer sleeve. After drilling, the drill sleeve is removed. Then an inner 4.5 mm tap sleeve
is inserted for tapping. The tapping sleeve is removed while maintaining the trocar sleeve (Fig. 5b). The screw can be inserted through this outer sleeve with a screwdriver, placing it correctly into the hole without losing it in the soft tissue (Fig. 5c).

3. Instruments to aid fracture reduction

3.1. Joystick T-handle (Fig. 6)

3.1.1. Principle

Direct fracture fragments manipulation can be done by using a Schanz screw and universal T-chuck with a detachable handle. The Schanz screw with an affixed T can be used as a joystick for fracture reduction by acting like a bone forceps (Fig. 6).

3.1.2. Technique

Predrill the bone fragments with a 3.5 mm drill bit, then insert the joystick T-handle into the bone fragment for direct fracture manipulation and reduction.
3.2. Wire passer (Fig. 7)

3.2.1. Principle
Reduction of a long oblique or spiral fracture with cerclage wires is a well-established technique. A conventional wire carrier is small, with a short curvature of the insertion handle. This design can be used for a widely exposed fracture. A new wire passer is fabricated by bending a Steinmann pin at the upper part and curving it at the lower part. The curve is larger than that of the conventional wire passer, with almost 3/5 of the circle able to pass over the femur. There is a hole at the tip of the wire passer which allows the wire to pass and bend after passing over the fracture. An incision for passing the wire is smaller than with a conventional open wiring, so that the muscle around the fracture zone can be preserved.

3.2.2. Technique
After making a 7–8 cm incision, a vastus sheath is incised and the muscle is longitudinally split with minimal cutting of the muscle. The wire passer is passed beneath the muscle and the tip is turned over the muscle on the medial side. After the tip passes through the muscle, the wire is then passed into the hole at the tip of the wire passer, and the tip of the wire is bent. The wire passer is removed by turning it backward along with the wire. This will make a wire loop over a fracture. The fracture is reduced and the wire is twisted to maintain the reduction (Fig. 8a–c).

Fig. 7. A conventional wire carrier with a small curve, and a wire passer with a larger curve and a longer handle.

Fig. 9. The plate distractor made from a damaged rib approximator.

Fig. 8. (a) The radiograph shows the spiral fracture of the proximal femur. (b) The wire passer passed over the fracture for reduction. (c) The radiograph shows the fracture after reduction.
3.3. Plate distractor (Fig. 9)

3.3.1. Principle

The function of the plate distractor is to distract the fracture and temporarily maintain the length of the fracture. The distractor is fabricated from a damaged rib approximator with the ratchet attached to two arms. One arm is for pushing the end of the plate and the other is for fixing to the bone with a Schanz screw distal or proximal to the plate end. The distractor is used for femoral and tibial fractures, which require enough distraction force to counteract the shortened muscle.

Fig. 10. The plate distractor applied to the distal part of the femur for reduction of the femoral shaft fracture.

Fig. 11. The tibial alignment grid.

Fig. 12. (a) The tibial alignment grid is placed under the tibia with the longitudinal K wire parallel to the tibial axis. (b) The radiograph of the knee joint shows the transverse K wire parallel to the knee joint. (c) The radiograph of the ankle joint shows the transverse K wire parallel to the ankle joint.
3.3.2. Technique

The plate is inserted into the submuscular tunnel. After fixing one end of the plate to the bone, with preliminary reduction by manual traction, the distractor is fixed to the other end. The plate cover end is inserted to push the plate, and the Schanz screw is fixed outside the plate. Turning the knob will lengthen and maintain the length of the fracture (Fig. 10).

3.4. Tibial alignment grid (Fig. 11)

3.4.1. Principle

Varus or valgus angulation can be evaluated intraoperatively by portable X-ray or an image intensifier. An image intensifier is more convenient to use intraoperatively but the entire length of the tibia cannot be evaluated in one or two X-rays. The tibial alignment grid is a helpful tool to evaluate varus or valgus angulation. It is made by mounting a vertical K-wire in the middle and parallel K-wires at a distance of 8 cm on each side of the vertical K-wire between two plastic plates (Fig. 11)3.

The tibial axis is determined by placing the grid under the tibia. A vertical K-wire is aligned to a long axis of the tibia (Fig. 12a). With the image intensifier perpendicular at the knee joint, the K-wire is set parallel to the joint line (Fig. 12b). Then the image intensifier is moved distally and placed it perpendicular to an ankle joint, and an X-ray is taken (Fig. 12c). When the K-wire at an ankle joint is parallel to the joint line, this means that the knee joint and the ankle joint are paralleled and the coronal plane alignment of the tibia is restored (Fig. 13).

Conflict of interest

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