Intraoperative Fabrication of Bone Tamps for Indirect Reduction of Depressed Articular Segments

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Abstract: The use of bone tamps for indirect reduction of depressed articular segments is an established method of treatment for intra-articular fractures in a variety of joint injuries. Customized bone tamps can be fabricated intraoperatively using commonly available instruments and supplies consisting of Steinmann pins and T-handled chucks. The technique combines the use of bone tamps through carefully created metaphyseal windows, fluoroscopic guidance, packing with cancellous bone, and adequate fixation. This treatment methodology can allow for a minimally invasive or soft tissue preserving approach for the treatment of some intra-articular fractures while achieving anatomic reduction of the joint surface.

Indirect reduction of depressed articular surfaces has been used in the treatment of articular fractures.\(^1,2\) Reduction is usually performed through a traumatologically or carefully created metaphyseal window through which the bone tamp is inserted. Several variables dictate the ideal choice of bone tamp, including the joint of interest, the size of the articular segment, the distance from the metaphyseal window to the articular surface, and the angle or curve of the tamp required to negotiate the window and impact the articular segment in the desired direction.

Several commercially available bone tamps of varying sizes and configurations exist and work effectively in most clinical scenarios. However, there are occasional scenarios in which these instruments are either not available or do not possess the ideal geometry needed to achieve reduction.

This article presents a technique that quickly and efficiently allows fabrication of bone tamps of varying sizes and geometry from readily available materials and tools in the operating room.

**MATERIALS AND METHODS**

Two patients underwent open reduction and internal fixation (ORIF) for traumatic articular joint-depression injuries of the distal tibia and distal radius, respectively. Treatment included the use of a novel technique using intraoperative fabrication and the use of customized bone tamps to assist in the reduction of depressed articular segments.

Preoperative plain radiographs and computed tomography (CT) were obtained for both patients. The first patient, a 29-year-old man, sustained a closed intra-articular comminuted distal radius fracture following a fall while snowboarding. Imaging revealed a volar Barton’s pattern with associated articular depression of the scaphoid fossa (Figure 1). The second patient, a
30-year-old man, sustained a closed intra-articular comminuted pilon fracture with associated articular depression following a fall from a bicycle (Figure 2).

At final follow-up, both patients were evaluated for fracture healing, accuracy of reduction, range of motion (ROM), pain, and return to preoperative function.

**SURGICAL TECHNIQUE**

Standard preoperative planning to include fracture templating, intended surgical approach, and selection of required implant and instruments is performed. In injuries with articular depression, preoperative planning may reveal an opportunity to perform a less invasive or indirect approach to achieving reduction of depressed articular segments. This reduction technique is achieved through the use of bone tamps. In addition to standard, commercially available equipment, bone tamps can be fabricated intraoperatively for specific joints and injury patterns.

The materials required are Steinmann pins of various diameters, wire or bolt cutters, and 2 T-handled chucks. The first step is deciding what diameter of Steinmann pin to use. In general, the larger the articular segment needing elevation and the larger the joint involved (ie, proximal tibia vs distal radius), the larger the Steinmann pin required. Caution is emphasized with this step because selection of a Steinmann pin with a relatively smaller diameter may result in perforation rather than elevation/reduction of the articular segment. A rule of thumb is to use a Steinmann pin with a diameter that is approximately one-third to one-half the width of the articular segment.

The next step is determining geometry of the fabricated bone tamp. This is based in large part on the location and size of the metaphyseal window relative to the articular segment requiring reduction. A metaphyseal window farther from the articular surface requires less curvature/bending than that of a window closer to the articular surface. The window created should remain in the metaphyseal region within the surgical incision; straying toward the diaphysis is undesirable due to the formation of a diaphyseal stress riser and greater difficulty in developing a window through cortical bone. However, the creation of the metaphyseal window does not need to be precise because the bone tamps can be adjusted as needed. The diameter of the metaphyseal window should be approximately twice the diameter of the Steinmann pin being used. If possible, the window should use openings already present in the metaphysis. The window is easily formed by using a postage stamp technique in which multiple holes are drilled in a circular fashion and completed with a quarter-inch osteotome (Figure 3). The cortex removed is later replaced following bone grafting and prior to plate fixation.

Once a particular diameter of Steinmann pin and a metaphyseal window is chosen, 2 T-handled chucks are attached to both ends of the Steinmann pin, and the pin is manipulated into the desired geometry (Figure 4). Finally, the tips of the pointed Steinmann pin are...
Cut off with the wire cutters or bolt cutters (bolt cutters required for diameters of 3.5 mm). The fabricated bone tamp is now ready for use and is inserted into the window to access the depressed articular segment (Figure 5). Further adjustments to the bone tamp can be made by simply reattaching the T-handled chucks and bending the Steinmann pin into the desired configuration.

Two specific clinical examples, including fractures of the distal radius and proximal tibia with depressed articular segments, highlight the use of this technique.

**Distal Radius**

A flexor carpi radialis approach was chosen to address the fracture. Manual reduction of the volar Barton’s segment was performed under direct visualization and provisionally secured using Kirschner wire fixation. Elevation of the depressed articular surface of the scaphoid fossa was performed through a 4.0-mm diameter metaphyseal window using a bone tamp fabricated from a 2.5-mm Steinmann pin (Figure 6A). Allograft cancellous bone chips were also used to backfill and assist with elevation of the articular segment. Finally, a volar locking plate was applied (Figure 6B).

**Distal Tibia**

Treatment occurred in a staged fashion, with initial placement of spanning external fixation the night of injury followed by ORIF after resolution of soft tissue envelope swelling. Intraoperatively, an anteromedial incision was used and reduction of the impacted anteromedial articular surface was performed under direct visualization. However, the posteromedial articular surface remained impacted and unreduced. Rather than addressing the unreduced segment through additional incisions, a 3.5-mm Steinmann pin was fashioned into a curved bone tamp and inserted through a metaphyseal window to achieve anatomic reduction of the articular surface (Figure 7). Postoperative radiographs show anatomic reduction of the articular surface with final fixation applied (Figure 8).

**RESULTS**

The technique was used successfully in both patients and allowed for anatomic reduction of the articular surfaces of the distal radius and distal tibia fractures. Both...
patients went on to uneventful healing of the fractures by 3 months with no complications. The distal radius fracture patient obtained full ROM and resolution of pain and returned to his previous level of activity. The pilon fracture patient obtained full ROM with minimal pain and returned to work.

**Discussion**

Articular fractures with areas of isolated depression can occur in multiple joints throughout the human body. Although differing joints are thought to have differing tolerances for residual incongruity after injury, it is accepted that a better reduction of articular incongruity generally results in better outcomes and likely decreased rates of traumatic arthritis.

Meticulous surgical technique must always be used when treating injuries with articular involvement. This includes a stepwise approach to fractures, including restoration of the metaphyseal region, adequate internal fixation, and the use of cancellous bone graft. Elevated articular segments require support by internal fixation and should be augmented with cancellous bone. In addition, if the fracture pattern shows widening of the metaphysis or if there exists a displaced articular portion with a metaphyseal/cortical attachment, reduction of these deformities must be performed before using bone tamps to elevate depressed articular segments.

Methods for reducing articular incongruity generally fall into 2 basic categories: direct and indirect. Direct methods include both open articular exposure via arthrotomy and visual evaluation of the articular surface. Arthroscopic visualization is also a form of direct means. Indirect methods generally include manipulation via ligamentotaxis or percutaneous or limited open approaches in which devices or instruments such as tamps, elevators, or pins are used. Surgeons using both methods often rely on radiologic imaging such as fluoroscopy or plain radiographs to judge the accuracy of their reduction but more so when using indirect methods.

There is also a recent trend in treating some fractures with less invasive or soft tissue-preserving techniques in the belief that these methods may result in lower rates of infection and soft tissue complications while preserving blood supply to fracture fragments. For surgeons who are proponents of these ideas and prefer to use indirect techniques for reducing certain articular injuries, our technique may help optimize the effectiveness of these techniques. The instruments for creating tamps are common items typically found in most hospital settings.

**References**

