How to Remove a Broken Single Transphyseal Screw

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1. Introduction

The surgical correction of angular limb deformities is performed primarily for cosmetic appeal and as a means of altering a conformation thought to be associated with musculoskeletal injuries incurred during an athletic career. A relatively small number of surgeries are performed to correct severe congenital or acquired angular limb deformities. Retardation or temporary arrest of growth on one side of a physis by mechanical restriction is a commonly employed technique in the surgical correction of angular limb deformities.

A variety of techniques using implants, placed so they bridge the convex or long side of an open physis at the site of deviation of the affected limb, have been described.1 These techniques employ the mechanical principle, whereby the cells producing growth by increase in length of the limb on the bridged side of the physis are temporarily compressed and inhibited. Growth continues on the contralateral side of the limb until the perceived deformity of the limb has corrected, at which time the implants are removed and normal growth is permitted to resume.2

The use of a single cortical screw to traverse and temporarily close the physis on the convex side of the limb has been well-documented in recent years.3–6 Implants that traverse or bridge an open physis must be removed promptly when the required degree of correction has been achieved, because failure to do so may result in overcorrection and deformity in the opposite direction. Implants still present at the time of radiographic closure of a physis are generally removed if the animal is likely to undergo a pre-purchase examination. Single cortical screws, placed so as to traverse a physis for correction of an angular limb deformity, are removed under standing sedation or general anesthesia, depending on the type of implant and location, surgeon preference, and temperament of the patient.

Complications associated with the placement and removal of a single transphyseal screw include breakage of the screw head or shaft and stripping of the screw head. Although these complications...
have been documented and a technique outlining removal of screws after stripping of the head exists within the literature, a comprehensive description of how to remove a broken screw does not exist.\textsuperscript{4,6–8}

The purpose of this report is to provide a concise description on how to remove a broken single transphyseal screw (Fig. 1). Other complications associated with screw removal will be briefly addressed.

\section{Materials and Methods}

If placing transphyseal screws for the correction of angular limb deformities, we recommend that one should be equipped with an extraction set\textsuperscript{a} and also be familiar with its use. The set is comprised of a T-handle with quick coupling, a hollow bone reamer, an extraction bolt, and a conical extraction device for threaded washers (Fig. 2). Additional equipment required includes a selection of bone chisels and curettes, countersink or bone gouge, and some finger retractors such as a pair of Senn or Mathieu retractors. Appropriate surgical draping, a 15T scalp knife, a balanced electrolyte solution with or without antibiotics, appropriate suture, and bandaging materials should also be at hand.

Intraoperative radiography is an essential component of successful screw extraction, and the process is greatly expedited through use of a digital system.

Surgical Procedure for Broken Screw Head (or Shaft)

Successful removal of a broken transphyseal screw requires that you have the necessary equipment at hand, that the patient is properly positioned under general anesthesia, and that there are appropriately trained assistants. Adequate personnel should include an anesthetist, surgical technician, assistant surgeon, and radiographer. All personnel involved in the procedure should be appropriately attired in lead aprons for the entire procedure.

The animal should be restrained in lateral recumbency under inhalant general anesthesia with the limb containing the implant in the uppermost position. If screw removal was initially approached with the horse standing, a light sterile bandage should be placed for induction of general anesthesia. The affected limb should be positioned so that both lateral to medial and dorsopalmar radiographs can be easily obtained without interfering with the surgical field.

After appropriate sterile preparation and surgical draping of the site and radiographic plate or panel, proper exposure of where the screw was placed is necessary. A 3- to 4-cm incision, centered over the head of the screw parallel to the long axis of the limb, is made down to cortical bone. The principle surgeon should be positioned so that the leading hand is closest to the limb (i.e., a right-handed surgeon should stand with his right side to the ventrum of the patient). This allows for easier alignment with the implant and the appropriate acute angle necessary for successful removal to be achieved.

With overlying soft-tissue layers retracted, the shaft of the screw is exposed. If necessary, a bone chisel or bone gouge may be used to expose the end of the remaining screw shaft. A reamer is then attached to the T-handle and fitted over the shaft of the screw, and a tract cut is made around the implant. It is important that the reamer follow the orientation of the screw without its teeth coming into contact with the shaft (Fig. 3). Contact be-
tween the two will result in damage to the cutting instrument and creation of metallic debris within the tract, which is extremely difficult to completely remove. Strong pressure and rotation in a counterclockwise direction is needed to ensure that the teeth of the reamer engage the bone and cut a tract. Regular orthogonal radiographic evaluation is necessary to ensure proper alignment of the reamer over the screw shaft (Fig. 4).

If a bend is present in the screw, as is often the case, reaming should continue just distal to the level of the bend, if possible, stopping just before the reamer comes in contact with the screw shaft. Failure to ream to this depth may result in breakage of the screw shaft at the bend during attempted extraction, resulting in the entire process having to be repeated.

After a tract has been reamed to the appropriate depth, the operator is ready to use the extraction bolt. This is attached to the T-handle and placed in the tract over the screw fragment. By pressing down strongly, the instrument is rotated in a counterclockwise direction until it engages the threads of the screw fragment. Because of the decrease in diameter of the extraction bolt from its mouth proximally, it rapidly tightens over the screw shaft (Fig. 5). Continued strong counterclockwise rotation and downward pressure will cause the screw to disengage from the bone and be removed (Fig. 6). If the screw breaks for a second time, the entire process should be repeated until all screw fragments are removed.

If metallic fragments remain within the tract, light curettage and copious flushing using a balanced polyionic electrolyte should follow until repeat radiographs confirm removal of all fragments (Fig. 7). The subcutaneous tissues and skin are closed in a routine manner, and the area is covered with a sterile bandage.

Postoperative care is as for standard screw removal, with bandaging continued for 2–4 wk. After stall rest with hand walking, regular turnout is resumed after suture removal 14-days post-operatively if healing is proceeding normally.
3. Results

Approximately 800 physeal bridging procedures, 500 of which involve the distal radial physis, are performed at Hagyard Equine Medical Institute each year for the correction of angular limb deformities using a single transphyseal screw. Of this number, it is estimated that screw breakage occurs in 3–4 patients each year, and using the technique outlined above, all broken screws have been successfully removed.

Intraoperative complications encountered during broken-screw removal included contact between the reamer and the screw, resulting in metallic debris scattered within the tract, and further breakage of the screw during attempted removal because of failure to ream beyond the bend in the screw. The metallic debris was removed by copious lavage and gentle curettage, whereas repeated breakage of the screw necessitated the entire process to be repeated.

Early post-operative complications included physeitis on the affected side of the limb, a prolonged period of lameness, and seroma formation. All postoperative complications responded favorably to conservative management, including stall rest and systemic anti-inflammatory drugs. Long-term cosmetic outcome was acceptable in all cases. Varying blemishes at the surgical sites were seen, but no overcorrection because of premature closure of the physis was noted. All horses fulfilled their intended purpose.

4. Discussion

The extraction set, comprised of a hand chuck, hollow bone reamer, extraction bolt, and conical extraction device for threaded washers, is available for both 3.5- and 4.5-mm cortical screws. Spare reamer tubes and extraction bolts should be kept in stock, because the teeth of the reamers are often damaged during the procedure and the screw may become permanently engaged in the extraction bolt. Synthes also supply a forceps for broken-screw removal, but the authors have not found this instrument to be useful for the removal of transphyseal screws.

The conical extraction device for threaded washers, provided with the extraction set, is used for screw removal after stripping of the screw head, the threads of which are orientated in the direction opposite to those of the screw. As a result of stripping of the screw head, the hexagonal head of the screw driver no longer fits snugly into the hexagonal indentation or recess within the screw head, known as the screw drive. The extraction device is inserted in the stripped screw-head indentation or screw drive and when turned in a counterclockwise direction, engages the screw head and tightens. Continued counterclockwise pressure applies an extraction force, and the screw is removed.

Although the distal radial physis is the most common physis temporarily bridged by single transphyseal screw placement, the frequency of screw breakage at this site is disproportionally high. In general, technique of screw placement greatly impacts the risk of screw breakage, but the duration of implantation, the age at implantation, and the length of screw used may all contribute to the in-
creased frequency with which screw breakage occurs at the distal radial physis.

Plastic deformation weakens the screw and may result in implant failure during removal. Plastic deformation of the head-shaft junction may occur because of uneven load sharing across the screw head or overtightening of the implant. Uneven load sharing may occur because of inadequate countersinking of the hole to accommodate the screw head. This may result from the head engaging the cortex unevenly as the screw is tightened or with continued growth, because the bone lengthens and places excessive stress on the screw head.1,9 Overtightening of the implant may arise because of the technique of placement or duration of implantation.

The original description of the technique described placement of the transphyseal screw in lag-fashion but has since evolved to positional screw placement for all locations, because it was felt the lag technique allowed overtightening of the implant at the time of placement or with continued limb growth.3,6 Also, after screw placement in lag fashion, the unfilled threads cut into the cis-cortex will fill with bone, producing difficulty in screw extraction, because this necessitates the threads cut their own way through the bone.5

Some of the authors of this report favor placing the screw fully (self-tapping), backing it out at least half its entire length, and replacing it again. They repeat this 2–3 times before replacing the screw to its full depth. After this, the screw is finally backed out one to two entire revolutions. It is speculated that both these steps in initial placement help seat the screw and facilitate removal.5 These methods in screw placement may wear down the threads cut into the bone and reduce the degree to which the threads fill with bone before implant removal.

Backling the screw out one entire revolution will result in the head of the screw being raised above the contour of the bone, resulting in a palpable protruberance beneath the skin, unless the hole was deeply countersunk. If it protrudes, the screw head may then act as a pressure point, resulting in skin necrosis. This can be avoided if the screw is placed palmar/caudal to the medial or lateral mid-point of the metaphysis.

It has been some of the authors’ experience that screws remaining across a physis for a period longer than 6–8 wk are at greater risk of breaking. The authors routinely monitor implants radiographically, particularly those implants bridging a physis for a period greater than 6 wk. The authors recommend replacing screws that show radiographic signs of bending or choose an alternative bridging technique entirely.

It is worth noting that screws have been placed across the distal radial physis in individuals up to 563 days of age, whereas patient age in individuals where screws are placed across the distal metacarpal or metatarsal physis usually does not exceed 112 days.4 The difference in patient age for screw implantation at both sites may also influence the frequency with which screw breakage is seen at each site. One would expect that, in older growing animals, the bone density would be greater and proportionately more torque would be required for screw removal.

The length of the screw used in the distal radial physis ranges from approximately 48 to 60 mm, whereas those implanted across the distal metacarpal or metatarsal physis range from 34 to 42 mm. Therefore, a greater length of bone-screw interface occurs with implants placed across the distal radial physis than those placed across the distal metacarpus/metatarsus, requiring greater torque for implant removal.

Appropriate post-operative bandaging will help limit the local tissue reaction and production of fibrous tissue that impedes implant removal.4,6 However, during the healing process, granulation tissue and periosteal callus may encompass the screw head and fill out the screw drive. This may result in difficulty locating and properly seating the end of the screwdriver in the hexagonal drive of the screw head. Inadequate seating can then lead to stripping or breakage of the screw head.1,4,11 To avoid either of these complications, it is imperative that encroaching bone and soft tissue in and around the head of the screw be removed before any attempt at screw loosening and removal. This is achieved through the use of intraoperative radiographic control using 18-gauge, 1.5-in needles as radiographic markers. Having located the screw head, a stab incision is made, and any fibrous tissue or periosteal callus occupying the screw drive or surrounding the screw head is removed using mosquito forceps, bone curette, or the tip of a hypodermic needle. Light tapping of the screwdriver with a hammer may help to seat the tip of the screwdriver in the head properly while also helping to disrupt any further callus that is impeding removal.4

In summary, recognizing the factors that may result in screw breakage, such as proper technique in position screw placement, suitable post-operative care, and a methodical systematic approach in locating and engaging the screw head during removal, is of paramount importance in avoiding complications associated with screw removal. If complications do arise, having the appropriate equipment and knowledge of the necessary techniques required for removal will greatly facilitate the operator in successfully removing the affected screw.

References and Footnote


“Synthes extraction set, Synthes Vet, West Chester, PA 19380."