Treatment of traumatic cranial fracture with sonic activated polymer pins and plates resorbable implants in a dog

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Behandlung einer traumatischen Schädelfraktur mit ultraschallaktivierten resorbierbaren Implantaten aus Polymerstiften und -platten bei einem Hund

Der Fallbericht beschreibt die Verwendung von ultraschallaktivierten resorbierbaren Implantaten zur chirurgischen Reparatur einer Schädeltrümmerfrakturen bei einem 10 Jahre alten mittelgrossen Mischlingshund, der durch einen Pferdetritt verletzt wurde.

Schlüsselwörter: Schädelfraktur, Bonewelding®, PDLLA, kraniomaxillofaziale Chirurgie, bioresorbierbare Implantate, interne Fixierung

Abstract

The case report describes the use of ultrasound-activated resorbable implants for surgical repair of comminuted cranial fractures in a 10 years old medium sized mix-breed dog being injured from a horse kick.

Keywords: skull fracture, Bonewelding®, PDLLA, craniomaxillofacial surgery, bio absorbable implants, internal fixation

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Introduction

Craniomaxillofacial (CMF) fractures are typically of traumatic origin in dogs and cats.[2,1] Blunt trauma, such as horse kicks, represent 13 % of all skull fractures aetiologies in dogs.[6] CMF fractures can cause patient disfigurement, inability to eat and drink, and respiratory issues due to upper airway obstruction. In human medicine, ultrasound activated resorbable implants are often applied in oral and craniomaxillofacial in non-loadbearing application sites.[14,9,5,11] A broad spectrum of surgical techniques has been used to repair CMF in veterinary medicine, such as external fixation, internal fixation via conventional plates, titanium miniplates and titanium mesh implants among others.[2,13,17,4,16] Nevertheless, the clinical use of resorbable implants has only been described in one case series from Langer et. al.,[8] where the authors reported the use of thermoplastic polymer resorbable and non-resorbable pins in combination with titanium mesh (Ti-Mesh) with minimal complications and a good cosmetic and functional result on long term follow up. The VetWelding® Resorb pins and plates (VetWelding® Technology AG, 8952 Schlieren/ZH, Switzerland) are made of a fully bioresorbable and biocompatible polymer, poly-D, L-lactic acid (PDLLA), which liquefies when exposed to ultrasonic energy. Plates are available in different shapes, sizes and thicknesses that can be contoured on the surgical site intraoperatively and adapt to each individual case. These plates are anchored through resorb pins that are fixed in predrilled holes. A so called "sonotrode" generates the ultrasonic energy and is applied to the pins that will bind with the selected plate and penetrate the cancellous bone providing fixation. This case report aims to document the application of a bioresorbable internal fixation implant for osteosynthesis of a comminuted CMF fracture in a dog and its outcome.

Case summary

A 10 years old, 21,5 kg weighted, intact mix breed female dog was presented to the emergency department of the Vetsuisse Faculty University of Zurich with head trauma after being kicked by a horse. The dog showed a perforating wound and minimal subcutaneous emphysema in the left ventral orbital region with the left eye showing mild hyphema. On careful palpation crepitus could be elicited extending from the nasal to the frontal bone, suggesting a comminuted fracture of these bones. The neurological examination showed mild neurologic deficits such as reduced pupillary reflexes and menace response. After initial stabilisation and monitoring overnight, a computer tomography (CT) scan of the head was performed on the next day. The

main findings included multiple bilateral comminuted depression fractures of *os nasale*, *os frontale, orbitae* and *os ethmoidale* and disruption of nasal *conchae dorsales* (Figure 1C, 1D). The ocular bulbs were intact, showing on both sides mild exophthalmos. Brain and subdural region were unremarkable in CT. Internal fixation of the main fragments was planned based on the imaging findings and surgery was performed 4 days after initial trauma. The dog was positioned in sternal recumbency and prepared for surgery. A dorsal approach to the fracture area was chosen (Figure 2A) and loose small bony fragments not useful for reconstruction were removed from the surgical field to avoid formation of bony sequestrum. The pin and plate system were implanted with the following procedure: A double row bioresorbable plate (length: 11×126 mm; thickness: 1 mm; V52-310-11-04, Vet-Welding®) was heated up in a hot sterile water bath (V52-400-10-04, Vet-Welding®) to be cut to the required size and contoured over the main fragments on the os nasale and os frontale (Figure 2B). Holes for the pins were pre-drilled into the bony fragments with a specific 1,6 mm drill bit (V52-616-04-07, Vet-Welding®). The ultrasonic energy was generated by an ultrasound generator (BoneWelder® Vet ultrasonic device, 01-01-001, Vet-Welding®) and applied via the specific handpiece (BoneWelder® Vet Handpiece, 01-02-001, Vet-Welding®). One handpiece tip, also known as sonotrode (Vet Standard Sonotrode, Straight; V52-501-21-04), was mounted onto the handpiece to transmit the ultrasonic energy. Each 2,1 mm x 4 mm resorbable pin (V52-521-54-04, Vet-Welding®) was mounted onto the sonotrode tip and inserted

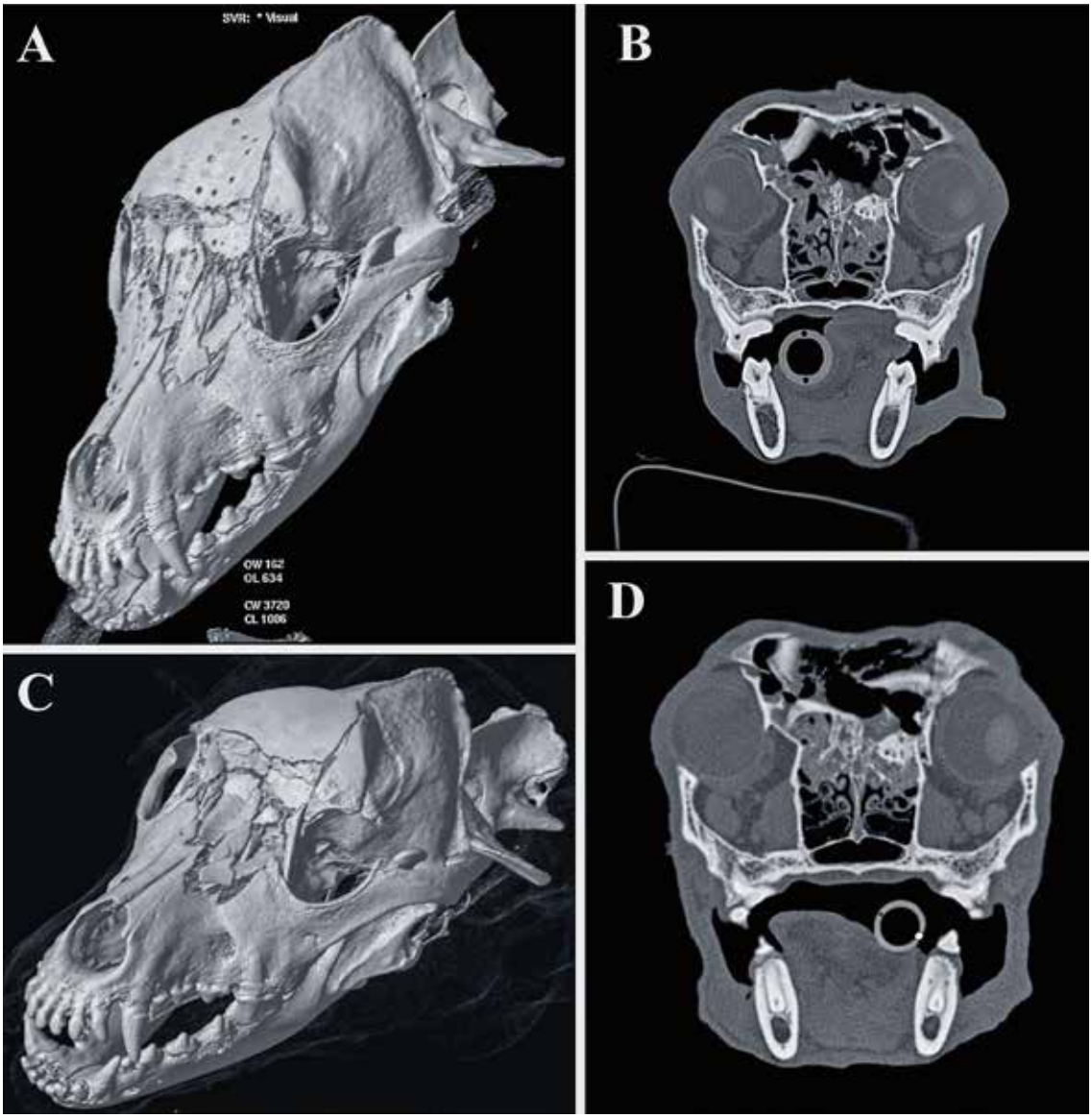

Figure 1: Three-dimensional (3D) computer tomographic (CT) reconstructions pre- (1C) and post intervention (1A). Transverse CT scan at eye level, showing the severity of comminution and displacement of bony fragments into the nasal cavity pre intervention (1D) and reduction post intervention (1B).

through the plate holes into the pre-drilled bone holes. The pushbutton of the handpiece was pressed to generate ultrasonic energy, which liquefied the polymeric components of pins, providing bonding of the pins to the plate. The liquid polymer flowed into the bony trabeculae where it solidified immediately, providing an anchorage of the plate to the bone. A second plate was placed adjacent to the first plate for fixation of the second large bony fragment (Figure 2C). The distal L-shaped plate end was welded to first plate with a 5 mm pin (V52-521-55-04, Vet-Welding®). A total of fifteen 5 mm pins and two 4 mm pins were used. After being flushed with sterile saline solution, the surgical site was closed routinely (Figure 2D). A comparative post-operative CT study was performed after surgery. The morphology and localisation of the implants was evaluated with standard sequences and 3-D reconstructions. The main fragments of the *os frontale* that were previously displaced into the nasal cavity and paranasal sinuses were reduced in normal position (Figure 1A, 1B). The dog recovered well from the procedure and was then discharged one day after surgery. Medical therapy with NSAID for 5 days (Robenacoxib 1 mg/kg p.o. SID, Onsior ad us. vet., Elanco Tiergesundheit AG, 4058 Basel, Switzerland, 20 mg), Gabapentin for 10 days (Gabapentin Mepha, 10 mg/kg, p.o, BID/TID, Mepha Pharma AG, 4051 Basel, Switzerland, 100 mg) and Antibiotics for 10 days (Amoxicilin-Clavulan acid, 20 mg/kg p.o, TID, Clavaseptin, Vetoquinol AG, 2018 Bern, 500 mg) was advised to be continued ad home. On a short term follow up control 5 weeks after surgery, the dog was recovering well and the owner did not express

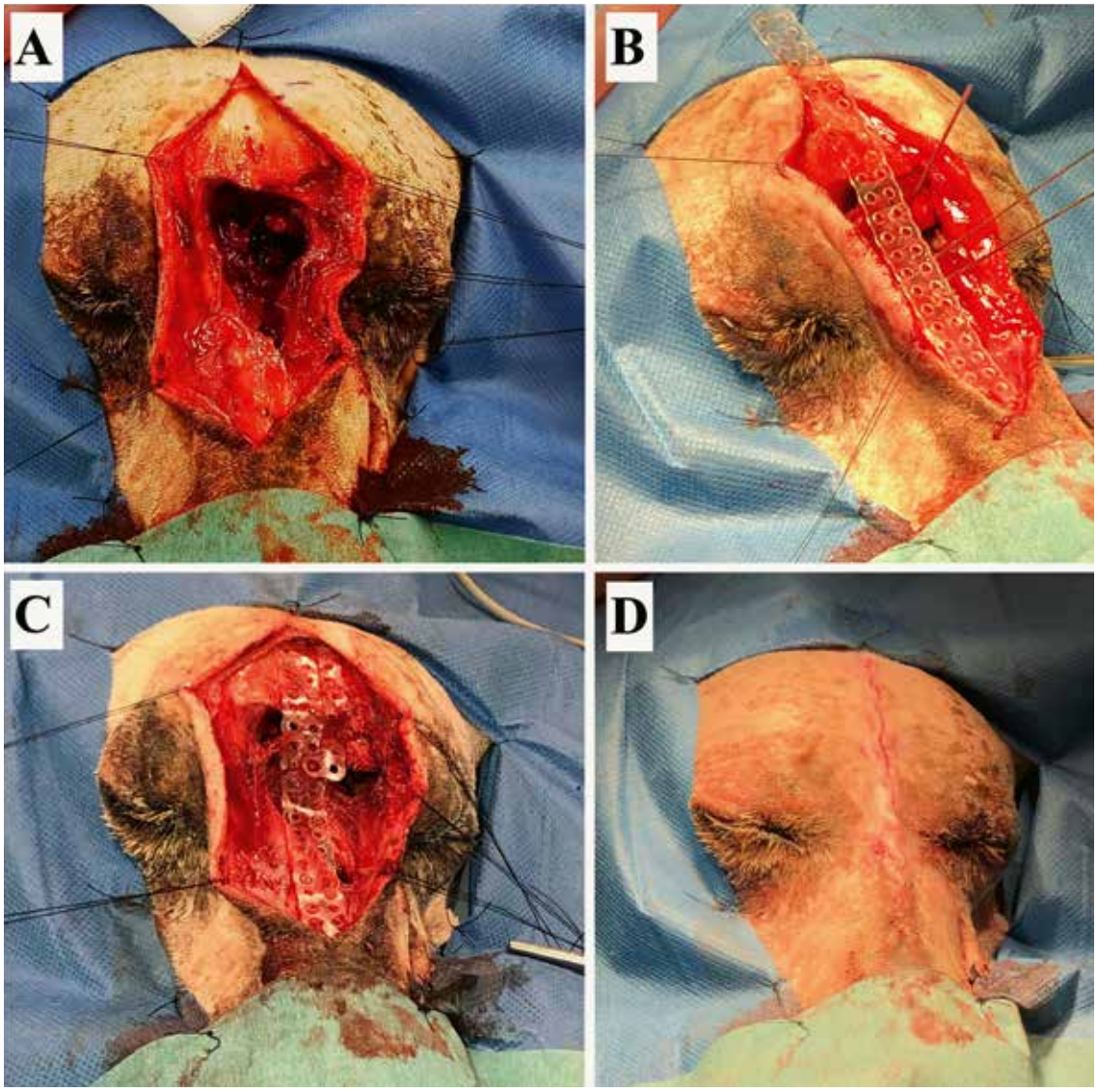

Figure 2: Intraoperative findings. Dorsal approach and exposure of the fracture site (2A). Intraoperative picture of contouring of one double row Vet-Welding® plate (2B). Intraoperative picture of the second single row Vet- Welding® plate placed adjacent to the first one (2C). Please note the reduction of the fragments into a normal position. Intraoperative picture of the closed surgical site (2D).

any concerns. On a long-term follow-up 3 months after surgery the dog was in good clinical condition and the owner did not report any clinical signs or pain, the wound also had a satisfactory cosmetic result (Figure 3).

Discussion

The skull is a complex bony structure that supports vital functions such as eating, breathing and offers protection for the brain. The decision to perform CMF osteosynthesis should take into account the main goals of repair, which are proper dental occlusion, stable skeletal fixation through reconstruction of the main buttress zones supporting the skull frame and prompt return to function.[2,17,3] Other important considerations are reconstruction of facial symmetry, protection of soft tissue structures such as vessels, nerves and the eye, as well as restoration of cosmesis. This case illustrates how resorbable osteosynthesis has been used to stabilise a comminuted fracture of the ethmoid, nasal bone, frontal bone and turbinates of the skull of a dog. These CMF fractures locations are uncommon, the frontal bone and the ethmoid are fractured with an incidence of respectively 17 % and 20 % all over all CMF locations[6] while nasal bone fractures are more common (31,5 %) but still less frequent compared to the maxillary bone (53,3 %), which is by far the most commonly fractured bone structure of the skull in dogs.[6] In this particular case, internal fixation of the main fragments was selected in order to restore cranial structure, provide sinus integrity, assure patency of the nasal cavity[12] and also prevent possible long-term complications arising from non-surgical treatment.[2] The most relevant complication considered for this specific case was the potential of fragment dislodgement and formation of sequestrums directed into nasal and frontal cavities.[2] Resorbable polymer pins were selected for this case considering the fractured region in combination with the advantages of the Bonewelding® technology, such as resorbability and biocompatibility,[1,7] minimal tissue trauma compared to traditional approaches, simple application process and procedural flexibility,[8] reduced implant insertion time and morbidity.[10,15] To the author's knowledge, no biomechanical study has been conducted on the most favourable size and thickness of these implants. However, the aim of this reconstruction was to restore the craniofacial vault. The Vet-Welding® plates comes in 1 mm and 1,5 mm thickness, therefore since the implants were not intended to withstand high mechanical forces, 1 mm thickness was deemed appropriate for this purpose. This case highlights how resorbable implant can be a reasonable choice for treatment of fractures with low mechanical load and less movement such as the one presented. It has to be taken into account, that the PDLLA polymer dissolves by hydrolysis in two and half to three months, which could be a disadvantage for bone region with higher force load that will not permit new bone formation and stabilization of the fracture on time. However, the frequent and safe use in humane medicine of resorbable osteosynthesis in CMF surgery is promising and encourages for a more frequent use of this technique in small animals. In conclusion, this is the first reported case where the pin and plates polymer system was used as single material and implant for internal fixation of a CMF fracture with successful fracture repair and prompt return to function as well as satisfying cosmetic appearance with no complications.

Figure 3: Picture of the female dog provided by her family three months post intervention.

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Traitement d'une fracture traumatique du crâne à l'aide de broches et de plaques résorbables en polymère activé par ultrasons chez un chien

Ce rapport de cas décrit l'utilisation d'implants résorbables activés par ultrasons pour la réparation chirurgicale de fractures crâniennes comminutives chez un chien de race moyenne âgé de 10 ans, blessé par un coup de pied de cheval.

Mots clés: fracture du crâne, Bonewelding®, PDLLA, chirurgie crânio-maxillo-faciale, implants résorbables, fixation interne

Trattamento di una frattura cranica traumatica con perni polimerici attivati a ultrasuoni e impianti riassorbibili a placche in un cane

Il rapporto di questo caso descrive l'uso di impianti riassorbibili attivati da ultrasuoni per la riparazione chirurgica di fratture craniche comminute in un cane di taglia media e di razza mista di 10 anni ferito da un calcio di cavallo.

Parole chiave: frattura cranica, Bonewelding®, PDLLA, chirurgia craniomassillofacciale, impianti bioassorbibili, fissazione interna

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