Tie-cross acrylic external skeletal fixator: Technique and 13 cases

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ABSTRACT

This study aims to describe a novel design of an acrylic external skeletal fixator (ESF) system for stabilizing epiphyseal/metaphyseal fractures with or without articular involvement and evaluate its efficiency in 13 cases. Client-owned five cats and eight dogs with epiphyseal/metaphyseal fractures were included in this study. Cross pins with or without a transcortical pin were included in "J" shaped acrylic ESF, and this novel technique was called the Tie-cross ESF. The functional use of the extremity was evaluated, and the joint range of motion was assessed and compared with the contralateral side. Radiographs were evaluated for bone healing and potential complications. The first use of the extremities changed from the day of surgery to the 3rd day. Fracture healing occurred in 35-69 days, and ESFs were removed. No persistent lameness was observed, and total functional recovery was provided in all cases. Fixation of epiphyseal and metaphyseal fractures can be challenging, especially when it involves the articular surface. Including cross-pins in an acrylic ESF (Tie-cross ESF) is useful and can be considered an alternative technique for stabilizing these fractures. This technique encourages the patient to use the extremity during the fracture healing and enables joint functions; therefore, additional physical therapy will not be necessary.

Introduction

Physeal, epiphyseal and metaphyseal fractures are common; some may include articular surfaces (8, 31). All fractures need complete anatomical reduction and stable fixation. However, it is necessary to secure the articular surface in complete anatomical position and normal axial alignment for intra-articular fractures to restore early joint mobility. Additionally, an immediate joint motion is necessary to prevent joint stiffness and ensure articular healing and functional recovery (2, 7, 25, 28, 36). Many techniques can be used to perform this goal (14, 18, 21, 23, 32).

Rush-pin or Cross-pin technique, if necessary, combined with a transcondylar screw or pin, is one of these methods frequently used for the stabilization of epiphyseal fractures with or without articular involvement (4, 6, 18, 30, 38). Cross-pining is sufficient with simple Salter-Harris fractures without needing an additional fixation method or a bandage. It encourages the patient to use its extremity step by step in the early healing period and enables joint functions. Complications of this technique include pin loosening, displacement of the pins, fixation failure, skin perforation, and soft tissue or/and bone infection (2, 3, 7, 8, 14).

Due to the possible complications mentioned above, we decided to include cross pins in an acrylic external skeletal fixator to prevent pin displacement. This novel technique was called "tie-cross" acrylic ESF. ESF is a non-/minimal-invasive technique frequently used in fractures to restore limb functions in the early period. The tie-in ESF is commonly preferred for comminuted fractures to collegiate bone fragments and segments. Therefore, we thought the tie-cross technique would also be a successful fixation method for epiphyseal and metaphyseal fractures with or without articular involvement.

Following the successful results in the first patient, this technique was also used on some patients, and fracture healing, joint range of motion, and functional recovery were evaluated clinically and radiographically.

Materials and Methods

Animals and case selection: The surgical protocol was approved by the Near East University animal care ethics committee (No: 27.11.2020/121). Before the procedures, patient owners were informed, and their signed consent was requested.

Eight dogs and five cats with an intra-articular or extra-articular distal or proximal part of femoral, tibial, or humeral fractures were included in this study. None of the patients had any life-threatening condition at the clinical presentation. Still, three cases (cases #7, 9, and 10) also had contralateral side fractures. Clinical and radiographical evaluations were performed as routine. Information about cases is indicated in Table 1.

Acrylic ESF Preparation: Commercially available self-curing, dental cold acrylic was used as an external frame. Liquid and powder were mixed with a ratio of 1:2, respectively. Because the mixture was liquid, to restrict the liquid acrylic before curing, it was first applied into a sterile endotracheal tube. The reason for choosing the endotracheal tube was that the tube was strong and flexible, and also sterile. Before this procedure, the tube had already been used as an external mold in the sterile surgical procedure as described below; pins were first passed through the endotracheal tube and the skin to the bone or drilled from the fracture line and then sent out of the skin and passed from the tube.

Surgical procedure: Before the surgical procedure, medetomidine (for cats: 100 mcg/kg IM, for dogs: 25 mcg/kg IM) and butorphanol (0.1 mg/kg SC) were administered for premedication, propofol (4 mg/kg IV) was used for induction, then patients were intubated, and anesthesia was maintained with sevoflurane in oxygen. Cefazolin (30 mg/kg IV) was used as a single shot before anesthetic induction. The surgical site was clipped and prepared for aseptic surgery as routine.

Tie-cross Acrylic ESF was performed in all cases with an open surgical technique (17). Following exposure of the fracture site, intra-articular (intercondylar or interfragmentary) fracture fixation was aimed first. For this, a threaded pin (Kirschner or Schanz) was first passed through the endotracheal tube and the skin (percutaneous). Then the pin was applied transcondylary to stabilize the two fracture fragments; before this, a pointed bone holding forceps was temporarily used to stabilize both condyles. During this application, utmost care was taken to bring every bone fragment to its exact anatomic place to avoid potential adverse effects on joint mobility. Then, with or without intercondylar fractures, the condylar segment's stabilization to the bone's main body was performed by cross-pinning. Although it varies according to cases, the cross pins were sent from the distal fragment to the proximal main segment (such as an anterograde pin application), as in the routine cross pin application, angled upwards from the lateral and medial sides of the condyles (Figure 1). It is also possible to apply the cross-pins in a retrograde fashion in femur and tibia fractures. Before being applied, pins were passed through the tube used as an acrylic mold.

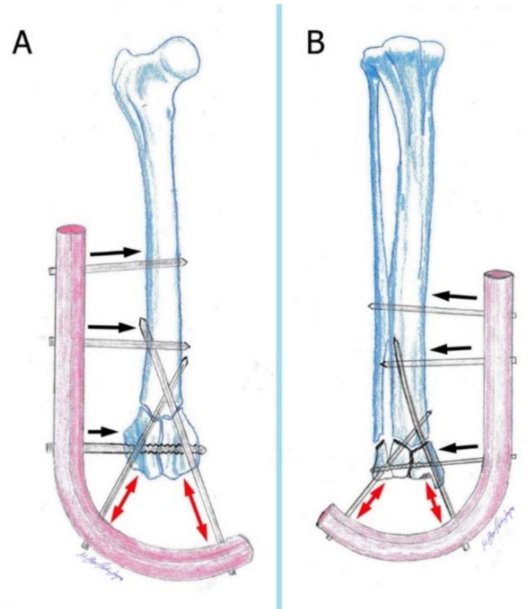

Figure 1. Cross-pins can be applied in both anterograde and retrograde fashion (red arrows) for femoral (A) and tibial fractures (B). If there is an intercondylar fracture, a transcondylar threaded pin should be applied before cross pins. Additional pins are sent above the fracture line from the tube to the bone (black arrow) to achieve a "J" shaped tie-cross ESF.

For humeral fractures, cross-pins were advanced from the fracture lines of each condyle (like retrograde pin application) and directed into the medullary canal of lateral and medial epicondylar crests. Then drilled out of the bone and the skin, passed through the plastic tube, and driven back from opposite ends until the inside ends aligned with the fracture line. Pins were advanced upward following fracture reduction to stabilize the condyles to the main body (Figure 2). Cross-pin ends were passed through the opposite cortex or driven into the medulla.

The plastic tube was bent in a "J" fashion for all patients, and additional pins were sent from the tube to the bone above the fracture line (Figure 3). Care was taken to keep an appropriate distance between the tube and the skin. Following the operation, the surgical site was sutured routinely, and cold-curing acrylic was prepared and injected inside the plastic tube. The acrylic body and pins were cooled with sterile saline to prevent possible thermal injury during the polymerization process of the acrylic.

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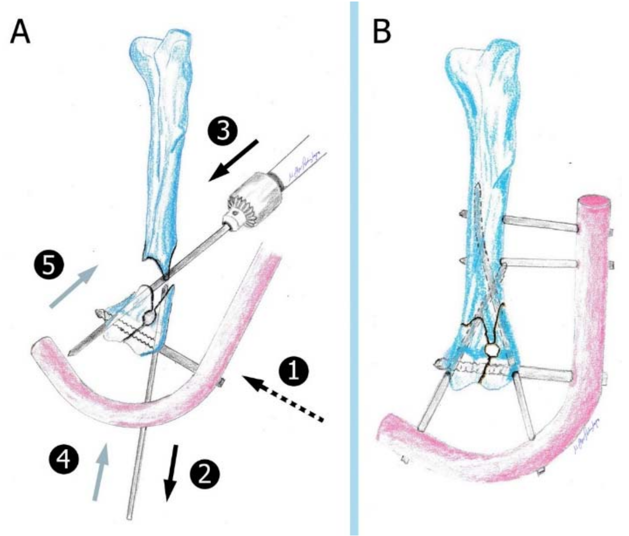

Figure 2. A. For humerus fractures following transcondylar pin application (dotted black arrow; no.1), two pins (black arrows; no. 2 and 3) are inserted into the lateral and medial epicondylar canals from fracture lines and drilled outside of the skin. Following reduction, these pins are driven into the main bone (grey arrows; no. 4 and 5) to achieve cross-pin fixation. B. After cross-pinning, additional pins are sent from the tube to the bone above the fracture line.

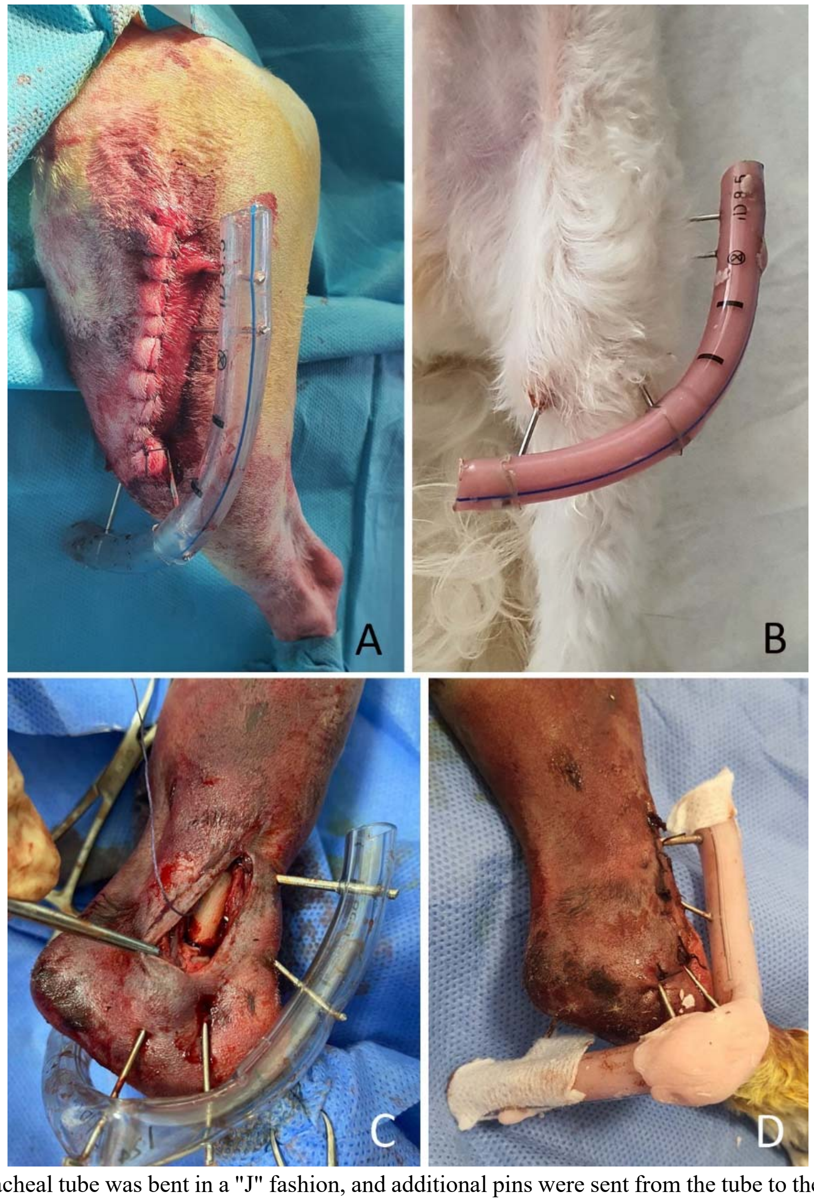

Figure 3. Sterile endotracheal tube was bent in a "J" fashion, and additional pins were sent from the tube to the bone above the fracture line (Case #13).
(A). In the same case before acrylic frame removal **(B)**. Intraoperative **(C)** and immediately after the surgery **(D)** views of Case #8; a sterile endotracheal tube was used to keep the liquid acrylic mixture in a mold.

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Postoperative Care: Following surgical procedures, postoperative radiographs were taken to evaluate the fixation further. Patients were hospitalized for ten days. Carprofen (3 mg/kg/day SC) for dogs and Meloxicam (0.2 mg/kg/day SC) for cats were preferred for pain management for 3-4 days. To keep the pin–skin interface clean, 10% povidone-iodine solution and a local antibiotic spray were applied daily. An Elizabeth collar was used for all cases to prevent any damage to the fixator and self-contamination.

At the end of the hospital care, patient owners were strictly informed about the daily care of the pin–skin interface until the removal of the fixator. During the treatment period, animals were not allowed to do any active exercise except for short leash walks, and they also were confined in a small place/room for six weeks.

Postoperative Evaluations: Postoperative clinical and radiographical evaluations were performed not in particular periods due to owners' and doctors' availability. Clinical assessments include the joint range of motion, functional use of the limb, fixator stability, and possible complications, such as any discharge in the pin-skin interface. Radiographical evaluations include bone and pins condition, fracture stability, and fracture healing.

Limb functionality and any lameness were evaluated and graded subjectively by two surgeons as described before (10, 26); excellent (no lameness, clinically normal), good (slight lameness after extensive exercise), fair (slight to moderate intermittent lameness but consistent weight-bearing), and poor (non-weight-bearing lameness). The joint range of motion was assessed by the method previously used by the authors (15, 24) with a plastic goniometer at different times; following surgery under general anesthesia, on the 10th day of hospitalization without sedation, and on the day of ESF removal under general anesthesia. The tie-cross acrylic ESFs were removed under general anesthesia after radiographically determined evidence of fracture union.

Results

Dogs' ages ranged from 7 months to 2 years, and cats' ages ranged from 3.5 months to 2 years. The cause of traumas was falling from high in cats and vehicular accidents in dogs. Weights ranged from 1.2 to 3 kg in cats and 4 to 29 kg in dogs.

Humerus fracture was determined in 8 cases (cases #1, 2, 3, 4, 5, 6, 9, 12), three of which were intraarticular. These were Salter-Harris type II (case #1), distal metaphyseal transversal (case #2), proximal metaphyseal oblique (case #3), condylar "Y" fracture (case #4), distal metaphyseal oblique fracture (case #5 and 6), Salter-Harris type IV (case #9 and 12) (Figure 4). A comminuted Salter-Harris type IV fracture of the distal tibia in case #7 and a distal metaphyseal short oblique fracture of the tibia and fibula in case #8 were determined (Figure 5). Femoral fractures were detected in 3 cases (cases #10, 11, and 13); all had Salter-Harris type I fracture (Figure 6). Three cases also had additional fractures of the contralateral side, including the pelvis and tibial fractures in case #7, a lateral condylar fracture of the right humerus in case #9, and a right side intraacetabular fracture in case #10 (Table 1).

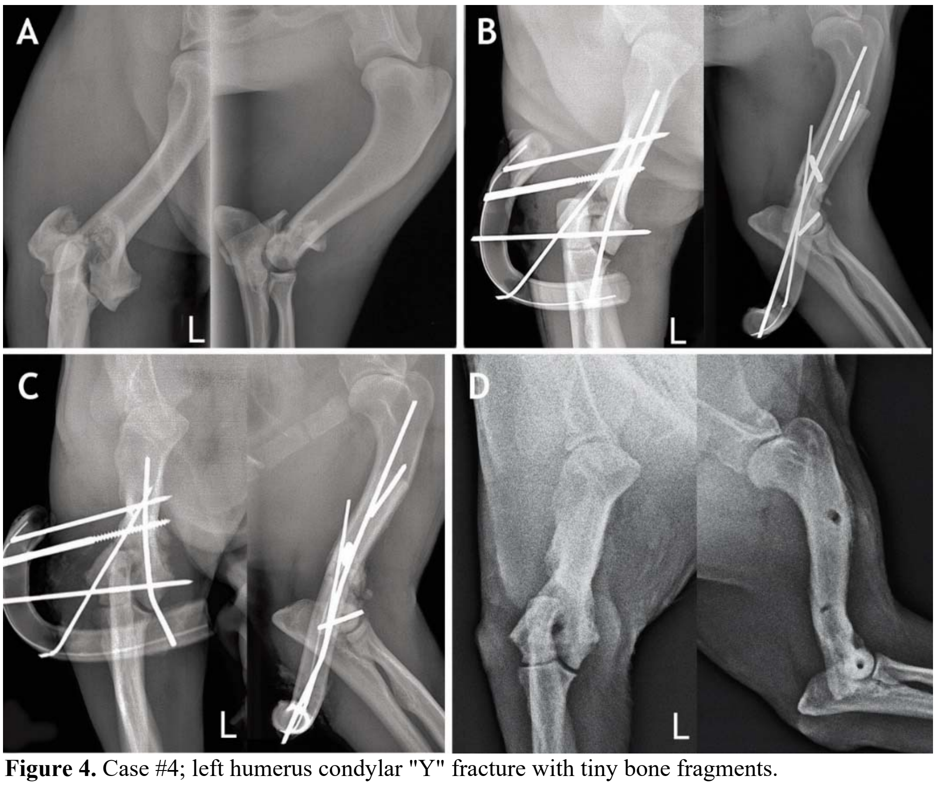

Figure 4. Case #4; left humerus condylar "Y" fracture with tiny bone fragments.
A. Preoperative, B. immediately after surgery, C. before ESF removal, and D. after ESF removal radiographs.

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Figure 5. Case #8; left tibia fibula distal metaphyseal short oblique fracture.
A. Preoperative, B. immediately after surgery, C. before ESF removal, and D. after ESF removal radiographs.

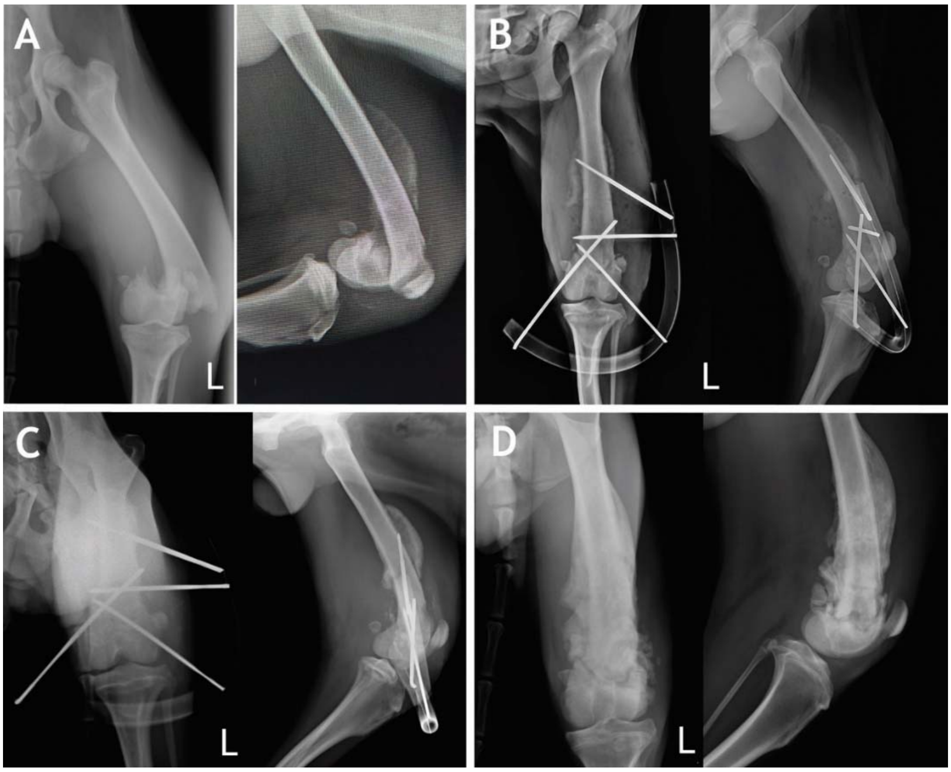

Figure 6. Case #10; left femur Salter-Harris Type I fracture.
A. Preoperative, B. immediately after surgery, C. before ESF removal, and D. after ESF removal radiographs.

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Table 1. Summary of information about cases.

Case	Signalment	History	Fracture localization and type	K-wire / pin size	Other fractures	Complications	First time to use the limb/fixation removal (day)	PROM / Limb functionality
1	Dog / Mix/ 23kg / 9 m. ♂	VA	Right **humerus** condylar Salter-Harris Type II	1.5, 2, and 2.5 mm	None	None	1/55	Elbow Flex 32° - Ext 164° / Excellent
2	Dog / Mix/ 27kg / 1.5 y. ♀	VA	Right **humerus** distal metaphyseal transversal (2nd surgery Tie-cross)	2.5 mm	None	None	1/49	Elbow Flex 34° - Ext 162° / Excellent
3	Dog / Mix/ 24kg / 7m. ♂	VA	Left **humerus** proximal metaphyseal short oblique	2 mm, and threaded 3 mm	None	None	0/35	Shoulder Flex 55° - Ext 166° / Excellent
4	Dog / French bulldog / 14 kg / 2 y. ♂	VA	Left **humerus** condylar "Y" fracture	2, 2.5 mm, and threaded 3 mm	None	None	0/63	Elbow Flex 37° - Ext 165° / Excellent
5	Cat / Mix / 3kg / 2 y. ♂	Fall	Left **humerus** distal metaphyseal supracondylar long oblique	0.8, 2 mm	None	None	1/45	Elbow Flex 24° - Ext 163° / Excellent
6	Dog / Mix/ 29kg / 8 m. ♂	VA	Right **humerus** distal metaphyseal supracondylar short oblique	1.5, 2, and 2.5 mm	None	Minor pin tract discharge, mild periosteal reaction, severe soft tissue reaction	2/41	Elbow Flex 39° - Ext 161° / Excellent
7	Cat / Mix / 3 kg / 8 m. ♂	Fall	Right **tibia** Salter-Harris Type IV, distal epiphyseal comminuted	0.8, 1.5, 2 mm, and threaded 1,2 mm	Right tuber ischii apophyseal fracture, left corpus ischii fissure, left tibia short oblique mid-diaphyseal fracture	None	1/69	Tarsal Flex 25° - Ext 165° / Excellent
8	Cat / Mix/ 3kg / 9 m. ♀	Fall	Left **tibia fibula** distal metaphyseal short oblique	0.8 mm, and threaded 1,2 mm	None	Frame-caused contact dermatitis	1/45	Tarsal Flex 22° - Ext 168° / Excellent
9	Cat / Mix/ 2kg / 4.5 m. ♀	Fall	Left **humerus** Salter-Harris Type IV, comminuted condylar "Y" fracture	0.8 mm	Right humerus lateral condylar	None	0/42	Elbow Flex 24° - Ext 164° / Excellent
10	Dog / Mix/ 26kg / 7 m. ♂	VA	Left **femur** Salter-Harris Type I	2 mm, and threaded 2,5 mm	Right intraacetabular	Minor pin tract discharge, severe periosteal reaction	2/50	Stifle Flex 45° - Ext 164° / Excellent
11	Dog / Mix/ 26kg / 9 m. ♂	VA	Left **femur** Salter-Harris Type I	2 mm, and threaded 3 mm	None	None	2/45	Stifle Flex 45° - Ext 165° / Excellent
12	Cat / Mix/ 1.2kg / 3.5 m. ♀	Fall	Right **humerus** Salter-Harris Type IV with segmented lateral supracondylar crest	0.8 mm, and threaded 1.2 mm	None	Minor pin tract discharge, mild periosteal reaction	1/52	Elbow Flex 22° - Ext 162° / Excellent
13	Dog / Terrier / 4kg / 9 m. ♂	VA	Left **femur** Salter-Harris Type I	2 mm	None	Minor pin tract discharge, mild periosteal reaction	3/40	Stifle Flex 40° - Ext 167° / Excellent

m. month, y. Year, VA vehicular accident, ♂ male, ♀female.

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Immediately after surgical procedures, postoperative examinations revealed no crepitus during joint movements but a slight decrease in range of motion because of tightness in periarticular muscles and postoperative edema. Additionally, the acrylic frame and construction of the tie-cross ESF were strong enough to be weight-bearing and allowed limb functions. After surgeries, radiographs revealed a good fracture reconstruction, even in intra-articular fractures, and no abnormalities such as articular involvement of a pin, and a fissure. Patients that recovered from anesthetic effects were allowed to leash walk on the same day. Three cases (#3, 4, and 9) started using their extremity at this time; two had an intraarticular fracture. Besides, all patients were willing to walk at varying degrees, including in three cases (#7, 9, and 10) with contralateral extremity fractures.

During the 10-day hospitalization period, limb functions and joint range of motion were evaluated (on the 10th day) and compared with the healthy side. Because of the post-surgical mild edema, the joint range of motion gradually increased from the day after surgery; however, animals did not allow evaluating the goniometric measurements while applying full extension and flexion of the affected side. Because of this fact, measurements were not consistent on the 10th day. Willing to walk and functions also gradually increased during this period. In addition to 3 cases (#3, 4, and 9) used their extremities on the same day of surgery, the remaining cases also started using their extremities on different days (Table 1); on the day after surgery (cases #1, 2, 5, 7, 8, and 12), on the second day after surgery (cases #6, 10, and 11), and on the third day after surgery (case #13). At the end of the hospitalization period, the patients were sent home, and their owners provided care.

Frame-caused contact dermatitis was observed in case #8 and eliminated by trimming the contacting side with an electrical bur and reinforcing the other side of the frame with the additional acrylic application.

During follow-up examinations, a mild pin tract discharge and soft tissue infection were observed in four cases (#6, 10, 12, and 13). These were probably due to the negligence of the patient owners, and/or these cases broke their hygiene. This complication was resolved by using oral antibiotics, cleaning the pin-skin interface, and covering the frame with a soft cloth. Mild to severe periosteal reactions were also encountered in mild pin tract discharge cases. This complication resolved gradually after the acrylic frame and pin removal.

On radiographic evaluations, fracture unions were good enough, and acrylic ESF frame and pin removal time ranged from 35 to 69 days. Following the removal of ESF under general anesthesia, passive joint range of motion (PROM) in maximal flexion and extension was evaluated with a standard plastic goniometer and compared with the opposite side. One shoulder, seven elbows, three stifles, and two tarsal joints were measured and compared to the opposite side (Table 1);

In case #1, PROM of the elbow joint for the affected side was Flexion 32° - Extension 164°, and the normal side was Flexion 32° - Extension 166°; *a slight difference in extension*.

In case #2, PROM of the elbow joint for the affected side was Flexion 34° - Extension 162°, and the normal side was Flexion 34° - Extension 165°; *a slight difference in extension*.

In case #3, PROM of the shoulder joint for the affected side was Flexion 55° - Extension 166°, and the normal side was Flexion 56° - Extension 165°; *a slight difference in flexion and extension*.

In case #4, PROM of the elbow joint for the affected side was Flexion 37° - Extension 165°, and the normal side was Flexion 36° - Extension 165°; *a slight difference in flexion*.

In case #5, PROM of the elbow joint for the affected side was Flexion 24° - Extension 163°, and the normal side was Flexion 22° - Extension 163°; *a slight difference in flexion*.

In case #6, PROM of the elbow joint for the affected side was Flexion 39° - Extension 161°, and the normal side was Flexion 36° - Extension 165°; *a slight difference in flexion and extension*.

In case #7, PROM of the tarsal joint for the affected side was Flexion 25° - Extension 165°, and the normal side was Flexion 21° - Extension 166°; *a slight difference in flexion and extension*.

In case #8, PROM of the tarsal joint for the affected side was Flexion 22° - Extension 168°, and the normal side was Flexion 24° - Extension 168°; *a slight difference in flexion*.

In case #9 with bilateral distal intra-articular humerus fracture, PROM of the left elbow (Tie-cross fixation) was Flexion 24° - Extension 164°, and for the right elbow (transcondylar and IM K-wire fixation) was Flexion 25° - Extension 163°; *a slight difference in flexion and extension*.

In case #10, PROM of the stifle joint for the affected side was Flexion 45° - Extension 164°, and the normal side was Flexion 42° - Extension 165°; *a slight difference in flexion and extension*.

In case #11, PROM of the stifle joint for the affected side was Flexion 45° - Extension 165°, and the normal side was Flexion 42° - Extension 165°; *a slight difference in flexion*.

In case #12, PROM of the elbow joint for the affected side was Flexion 22° - Extension 162°, and the normal side was Flexion 22° - Extension 164°; *a slight difference in extension*.

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In case #13, PROM of the stifle joint for the affected side was Flexion 40° - Extension 167°, and the normal side was Flexion 35° - Extension 170°; *a slight difference in flexion and extension*.

Discussion and Conclusion

Reconstruction and stabilization of physeal, epiphyseal and metaphyseal fractures of bones are more challenging, especially if this fracture involves the joint. However, orthopedic surgeons can tackle this by using many techniques or combinations (2, 3, 7, 8, 14). Cross-pin, cross-pin with a transcondylar pin or screw, bone plate, bone plate with a transcondylar pin or screw, and external skeletal fixators can be preferred for this purpose (12, 18, 23, 30, 31). A bone plate is a suitable fixation method but sometimes can not be affordable for owners or not to be applicable for some complicated intra-articular fractures. Fixation of these fractures with transcondylar screws and cross-pins is less traumatic, less costly, and strong enough to stabilize bone fragments; however, pin loosening and migration, skin laceration, and soft tissue and bone infection can sometimes happen as technical complications. Therefore, in this study, we preferred to connect cross-pins with an acrylic ESF to prevent any possible pin migration and subsequent complications. Besides, with this method, we aimed that animals could have an opportunity for early use of their extremity.

An additional immobilization with a splinted bandage can be preferred to support the fracture and its fixation postoperatively. Although a splint may help fracture union, it will prevent joint function, which is especially crucial for functional joint recovery in intra-articular fractures. It causes a significant decrease in the joint range of motion, loss of function, and permanent lameness (14, 36). To prevent these possible complications, cross-pins were included in the acrylic ESF; the stabilization was strong enough and encouraged our cases to use their extremities in the early recovery period. An additional immobilization method will not be necessary with this technique.

Fractures involving the articular surface should be reduced anatomically and fixed securely to protect the ideal reduction. Otherwise, deformity, joint stiffness, posttraumatic arthritis, and permanent pain will lead to constant lameness. Providing normal axial alignment and initializing early joint motion will allow excellent functional recovery. An immediate joint motion is also necessary to prevent joint stiffness and ensure articular healing and functional recovery (25, 28, 35, 36). In this study, cases #4, 7, 9, and 12 had intra-articular fractures. With this technique, an ideal anatomical reduction could be achieved in these cases with intra-articular fractures. Additionally, these patients used their limbs functionally, and we observed that the first time to use the limb was on the same day of the surgery in two cases (cases #4 and 9) and the day after surgery in cases #7 and 12. Early functional recovery was also recorded in the remaining cases. Deformity, joint stiffness, posttraumatic arthritis, pain, and lameness were not observed in any of these cases. Additionally, in the remaining cases without articular surface involvement, the day of first use of the extremity ranged from 0-3 days.

Several external fixator systems have been available for human and animal orthopedic fracture repair management for a long time, and the advantages and disadvantages of ESF are well known (9, 14, 16, 29, 33). ESF can be preferred for reconstructing intra/extra-articular epiphyseal/metaphyseal fractures, with or without additional techniques. For intra-articular fractures, the joint movements can also be temporarily blocked by the transarticular ESF. In this way, an orthopedic surgeon achieves intra-articular fracture stabilization until adequate bone healing but temporarily prevents joint functions. Following the removal of transarticular ESF, an inevitable decrease in joint range of motion and a weight-bearing lameness will resolve within weeks with additional physical therapy, and the joint will become functional (13, 16, 19, 20, 22). Possible complications of the tie-cross acrylic ESF are the same as the complications described for other forms of ESF. Disadvantages and advantages are the same; additionally, unlike transarticular ESF, tie-cross ESF allows joint functions. In our study, we observed that the tie-cross acrylic ESF encouraged animals to use their joints in the early healing period. Therefore no additional physical therapy was required after ESF removal. Besides, the joint range of motion in the affected extremity was within normal limits.

In the Tie-in ESF technique, an IM pin is included in the ESF system. This way, diaphysis or metaphyseal fractures (comminuted or not) can be successfully managed (1, 11, 14). In this study, cross pins were included in the ESF system, and it was called Tie-cross ESF. The advantages and disadvantages are the same for all ESF systems. However, an orthopedic surgeon will have extra benefits from tie-cross ESF, especially comminuted fractures close to the joint. Like other ESFs, tie-cross ESF will also provide bone integrity until fracture healing and allow patients to use their extremities. Furthermore, this technique will prevent cross-pin loosening and migration complications. Additionally, in case of comminution of epiphyseal or metaphyseal bone, the acrylic frame will also provide rigid external stability and will hold the fractured bone in reduction.

The mechanical properties of an acrylic external fixator vary according to its configuration; however, it is strong enough to bear weight even in large animals. Although its advantages and disadvantages are almost the same, unlike metallic fixators, it is quite inexpensive, easy to obtain, and easy to connect pins in different directions (5, 11, 34, 37). The acrylic bar is also used for the tie-in configuration (11, 27). Besides the high probability of pin migration in the cross-pin application, the successful results obtained in the tie-in technique and the use of acrylic as an external fixator for many years also encouraged us to develop this new technique. Additionally, we didn't encounter any acrylic frame failure in our cases in different weight scales. During the procedure, it was fairly easy to connect pins with the tube.

In conclusion, there are many techniques to manage epiphyseal and metaphyseal fractures with or without comminution, or articular involvement. This technique distinguishably differs from other ESFs because in this technique, cross-pins were included in an acrylic ESF frame (unilateral uniplanar, a Type 1a external fixator). Therefore, calling this new ESF configuration the "tie-cross ESF" was necessary. This technique can also be achieved with metallic ESF frames and connectors. However, an acrylic ESF will be cheaper and more flexible to include all pins. Additionally, tie-cross ESF will provide an early gain of joint functions, which is crucial for articular bone healing. Therefore, additional physical therapy will not be necessary after ESF removal.

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Conflict of Interest

We declare that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Author Contributions

MAÇ came up with the idea of this technique and study design. GY and MAÇ carried out the surgical technique. GY and MAÇ performed the measurements and clinical assessments. GY and MAÇ evaluated and interpreted data and radiographs. GY and MAÇ contributed to writing and editing the original draft of the manuscript. GY and MAÇ reviewed and approved the final manuscript.

Ethical Statement

This study was approved by the Near East University animal care ethics committee (No: 27.11.2020/121).

Animal Welfare

The authors confirm that they have adhered to ARRIVE Guidelines to protect animals used for scientific purposes.

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