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Comparison of a Hybrid Intramedullary Pin with External Fixation Procedure and a Tape Splint on Tibiotarsal Fractures in Budgerigars (*Melopsittacus undulatus*): A Retrospective Study

Muhabbet Kuşlarının (*Melopsittacus undulatus*) Tibiotarsal Kırıklarında Intramedüller Pinle Yapılan Eksternal Fikzasyon Hibrit Tekniğiyle Bant Atelinin Karşılaştırılması: Retrospektif Çalışma

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ABSTRACT

Comparing the short-term clinical outcomes of a tape splint, and the hybrid intramedullary pin with external fixation procedure (IMEF), a surgical approach, in the treatment of tibiotarsal fractures (TTFs) in budgerigars, and to present predictors of TTFs are objectives of this study. A total of 20 budgerigars admitted to the animal hospital with TTFs, which were treated with either the tape splint (n = 11) or IMEF (n = 9) surgery were material of the study. The treatment outcomes of both methods were compared, along with fracture predictors. The success rate of the IMEF surgery and tape splint were 6/9 (66.7%) and 9/11 (81.8%), respectively. The two methods were found to have similar success rates when compared to each other (odds ratio: 0.44, $P = 0.39$). The most common fracture location was the mid-shaft of the tibiotarsus for both treatment groups (IMEF: 6/9, 66.7%; tape splint: 7/11, 63.6%). The most common fracture type was oblique fractures in the IMEF surgery group (5/9, 55.6%), while it was transverse (8/11, 72.7%) in the tape splint group. There was a weak correlation ($r = 0.41$, $P < 0.03$) between the location of the fracture and the fracture type in both groups. In conclusion, both the IMEF surgery and tape splint methods have similar outcomes. The tape splint method should be preferred as the primary treatment option due to its non-invasive nature during TTFs in budgerigars. The IMEF surgery may be considered for the treatment of displaced fractures, but the involvement of the hock and stifle joints should be considered.

Keywords: Avian, budgerigar, fracture, *Melopsittacus undulatus*, osteosynthesis, tibiotarsus

ÖZ

Bu çalışma, cerrahi barındırmayan bir eksternal koaptasyon tekniği olan bant ateli ile cerrahi bir yöntem olan intramedüller pinle yapılan eksternal fikzasyon hibrit tekniğini (IMEF) karşılaştırmayı ve muhabbet kuşlarının tibiotarsal kırıklarına (TTFs) sebep olan öncülleri incelemeyi amaçlamaktadır. Bu çalışmanın hayvan materyalini hayvan hastanesine TTFs şikayetiyle başvuran toplam 20 muhabbet kuşu oluşturmaktadır. Tibiotarsal kırığı bulunan kuşların tedavileri IMEF (n = 9) ya da bant atel (n = 11) yöntemlerinden birisi tercih edilerek yapıldı ve her iki girişim tekniğinin sonuçları ve kırığa neden olan öncüller karşılaştırıldı. Elde edilen bulgular incelendiğinde IMEF cerrahisinin 6/9 (%66,7) ve bant atelinin 9/11 (%81,8) olduğu ve iki yöntemin birbirine kıyaslandığında başarı oranlarının benzer olduğu gözlendi (*Odds oranı*: ,44, $P = ,39$). Her iki yaklaşım tekniğinde de en sık görülen tibiotarsal kırık midşaft kırığıydı (IMEF: 6/9, %66,7; bant ateli (7/11, %63,6). En sık görülen kırık şekli de IMEF cerrahisi ile sağaltılan grupta oblik kırık (5/9, %55,6) ve bant ateli sağaltım grubunda transversal kırık (8/11, %72,7) olduğu gözlendi. Her iki grupta da kırık yeri ile kırık şekli arasında zayıf bir korelasyon olduğu belirlendi ($r = 0,42$, $P < ,03$). Sonuç olarak IMEF ve bant ateli birbirine benzer sonuçları olan iki yöntemdir. Bant ateli yöntemi invaziv olmaması nedeniyle öncelikli olarak tercih edilmelidir. IMEF cerrahisi yalnızca deplase kırıklarda önerilebilir olsa da eklem içerisinde invazyona neden olma potansiyeli göz önünde bulundurulmalıdır.

Anahtar Kelimeler: Kanatlılar, kırık, muhabbet kuşları, *Melopsittacus undulatus*, osteosentez, tibiotarsus

INTRODUCTION

Tibiotarsal fractures (TTFs) are common health issues encountered in budgerigars.[1-3] Trauma, nutritional deficiencies, poor body condition, chronic diseases, stress, and a crowded environment are the leading causes of TTFs.[1,4] The principles of treatment for TTFs generally follow small animal medicine. However, the size sometimes limits the approach with avian patients.[5]

In the case of TTF in birds, the treatment options are usually cage rest, external coaptation, and surgery.[4] The tape splint is a standard external coaptation method for the treatment of minimally displaced fractures in birds.[1] This technique minimizes the compression, rotation, and bending-shearing forces of the fracture site and promotes bone healing.[6] Tape splinting is preferred among clinicians because of its cost, ease of application, good tolerance by the patient, and generally satisfactory results.[7] However, due to poor anatomical alignment and a lack of rigid fixation of fragments, tape splinting can result in complications such as deformity and malunion.[7,8]

Although external coaptation is a good option for minimally displaced fractures, internal fixation in displaced fractures has some advantages, including immediate fracture stabilization, anatomical alignment, potential rapid healing, and minimization of bone healing complications such as malunion and nonunion.[4,8,9]

Although several surgical techniques have been investigated for the fixation of TTFs in birds, including intramedullary interlocking nails,[10] titanium microplates,[11] type II external skeletal fixators,[12] and external skeletal fixator intramedullary pin tie-in,[13] not all of them are suitable for budgerigars. The most common way to treat TTFs in budgerigars is nonsurgical external coaptation. This method has not yet been compared to a surgical method, nor has the use of a surgical technique in the clinical field with budgerigars been described.

The aim of this study was to present the short-term clinical outcomes of a tape splint, a nonsurgical external coaptation technique, and a comparison of the hybrid intramedullary pin with external fixation procedure (IMEF), a surgical approach, and predictors of TTFs in budgerigars.

MATERIALS AND METHODS

The study was performed in a Veterinary Teaching Hospital with the approval of the Atatürk University Local Ethics Council of Animal Experiments (HADYEK decision no: 2021/275).

Animals

Twenty budgerigars (*Melopsittacus undulatus*) were admitted to the Veterinary Teaching Hospital by their owners for TTF treatment and were included in the study.

Study Design

In this study, the cases were randomly assigned to receive either the IMEF or tape splint treatment methods. The inclusion criteria for this study were the presence of a displaced or nondisplaced complete fracture as observed on radiography. Cases with multiple fractures, multi-fragmentary fractures, or open fractures were not included in the study. Patient demographic data, such as age, sex, affected leg, cause of fracture, fracture location, and fracture configuration, were obtained from hospital records.

The operator determined outcomes on the 21st day when pins and splints were removed from both groups owing to weight bearing on the leg.

Preoperative Preparation

Before undergoing IMEF surgery or tape splint treatment, patients were required to fast for 5 hours and have their crop palpated to ensure they were empty. Preanesthetic considerations were assessed through anamnesis, assessment of the patient's awareness and environment, auscultation of the heart and respiratory system, evaluation of hydration and nutritional status, and palpation of the abdominal organs for any enlargement. The feces were also observed for color. Ventrodorsal and lateral orthogonal radiographs in dorsal and lateral recumbency were taken to check for any signs of masses such as eggs, lipomas, granulomas, ingrown feathers, or feather cysts.

Anesthesia was induced using a mask created by attaching a bandage roller to an anesthetic device (Komesaroff Mini-Kom, Kruuse, Langeskov, Denmark) and administering 4% sevoflurane (Sevorane 100% Inhalation Solution, Aesica Ltd, Queenborough, England) in pure oxygen at a flow rate of 2 L/min, while the patient was held wrapped in a towel or by hand (Figure 1A). Once the patient's respiration became regular and flapping movements ceased, it was placed in dorsal recumbency on the surgery table. The wings, feet, and tail were then taped onto the surgery drape (Figure 1B). Anesthesia was maintained using sevoflurane (2.5% in pure oxygen at a flow rate of 1.5-2.5 L/min) through the mask until the surgery or tape splint treatment was completed.

Tape Splint Procedure

A modified Altman's splint,[14] in the form of an external coaptation bandage, was applied to the site of the fracture. This bandage covers both the distal and proximal joints in relation to the fracture line. Radiographs were obtained immediately postfixation and again on the 21st day for all patients.

Hybrid Intramedullary Pin with External Fixation Procedure

The claws were grasped with gauze soaked in povidone–iodine (Dermosept Baticonol, 10%, ALG İlaç Ltd, İstanbul, Türkiye). Feathers were plucked around the leg, and the entire leg was prepared with 10% povidone–iodine followed by 0.4% chlorhexidine (4%, Klorhex, Drogsan, Çubuk, Ankara, Türkiye). The claw was grasped with sterile forceps through an opening on a presterilized transparent oven cooking bag (drape) (Figure 1C). Peripheral intravenous catheter guidewires (Nextech Medical Ltd Company, İstanbul, Türkiye) ranging from 0.4 mm to 0.5 mm were prepared for intramedullary pinning. A 1.5 cm incision was made at the craniomedial side of the affected leg. Fragments were identified between the *m.gastrocnemius medialis* and *m.tibialis cranialis* using Adson forceps. The trocar tip of the pin was advanced into the intramedullary canal of the distal fragment in a retrograde fashion, with the hock joint flexed to > 90° (Figure 1D). The pin was then advanced distally through the joint, and the stifle joint was flexed. The trocar tip was advanced into the proximal fragment and exited the skin through the cranial aspect of the tibial plateau (Figure 1E). The pin was not completely pulled out at this stage; the blunt tip of the pin was inserted into the distal fragment and advanced in a retrograde fashion through the previously created tunnel. The distal tip was pulled out until the pin length exiting distally and proximally was equal (Figure 1G). The proximal and

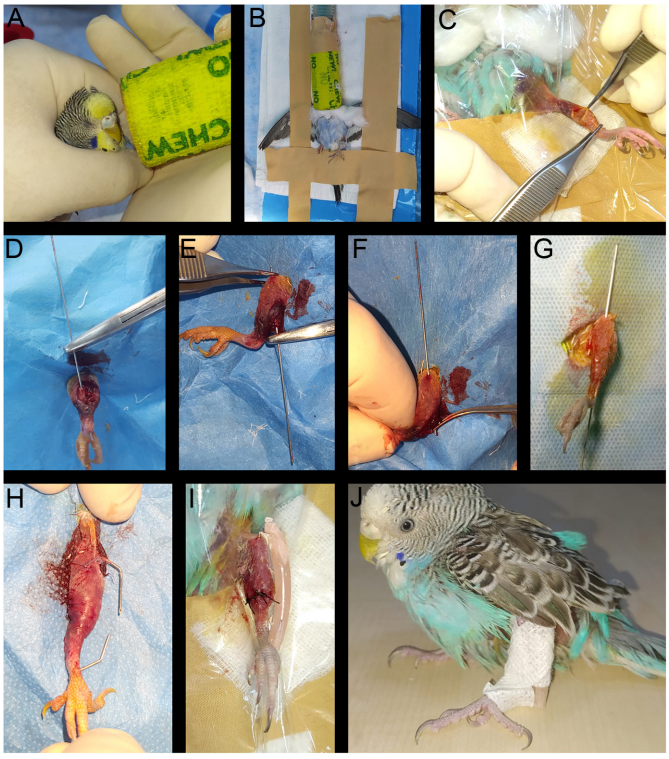

Figure 1. Hybrid intramedullary pin with external fixation procedure (IMEF) in budgerigars. (A) The induction was performed in hand with sevoflurane (4% in pure O_2 with a 2 L/min flow rate) until the excitation phase ended. (B) The bird was placed dorsal recumbency on the surgery table after inducing with anesthesia and taped. (C) A presterilized, transparent commercial oven bag used for under-drape monitoring. (D) Retrograde pin insertion. (E) Care was taken to protect the medial metatarsal vein while the pin was pulled out. (F) Replacement of the pin in the stifle joint. (G) The distal tip was pulled out until the sizes of the outer portion were equal. (H) Proximal and distal tips bent toward each other on the lateral side of the leg. (I) A piece of intravenous set hose was filled with polymethylmethacrylate cement, and pin tips were embedded inside the acrylic cement to fix each other with an acrylic–pin external fixator configuration (APEF). Then the skin was sutured. (J) A piece of adhesive tape was placed around the tibiotarsal and tarsometatarsal skin and secured to the APEF configuration.

distal tips of the pin were bent toward each other on the lateral side of the leg (Figure 1H). A piece of intravenous fluid administration hose was filled with polymethylmethacrylate cement, and the pin tips were embedded inside the cement to fix each other in an acrylic–pin external fixator (APEF) configuration. The skin was then sutured (Figure 1I). A piece of adhesive tape was placed around the tibiotarsal skin and taped to the APEF configuration (Figure 1J), and a secondary piece of tape was taped to the tarsometatarsal skin to prevent the medial rotation of the leg at the pin axis, then placed around the APEF configuration. The surgery was completed. Immediate postfixation radiographs were taken.

On the 21st postoperative day, the patient was anesthetized again for pin removal (Figure 2C). The pin sites were debrided with ethanol (96%, Etil Alkol, Alkomed Kimya, İstanbul, Türkiye) in a water solution (70%) (Figure 2D). The proximal tip of the pin was cut with a wire cutter without crushing or bending and then pulled out from the distal aspect (Figure 2E and F).

Postoperative Period

The following actions were taken after the collection of postoperative radiographs (Figure 2A and B); the patient was wrapped in

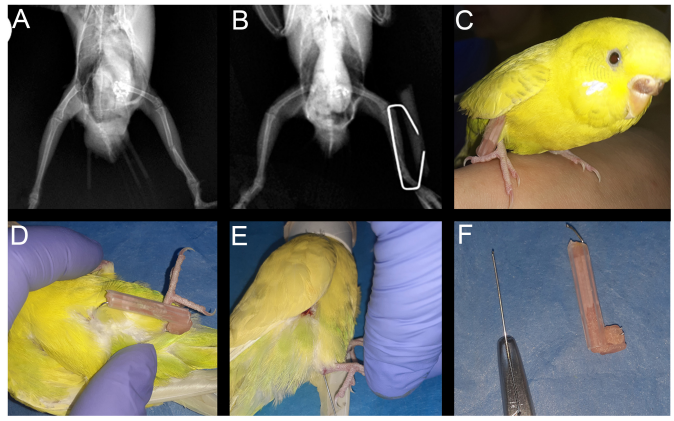

Figure 2. Postoperative management after the hybrid intramedullary pin with external fixation procedure (IMEF) in budgerigars. (A) Preoperative radiograph. (B) A radiograph 21 days after surgery. (C) Patient before the pins were pulled out. (D) Anesthetized patient for pin removal. (E) The proximal tip of the pin was cut without crushing or bending and pulled out from the hock joint. (F) Pulled pin and an acrylic–pin external fixator configuration.

a towel and taken to a prewarmed incubator for a smooth recovery. Butorphanol (1 mg/kg, IM, q12h, ×4, Butomidor, Richterphar Up, Wels, Austria) and Oxytetracycline HCl with vitamin combinations (30 mg/kg, PO, q24h, ×5 days, Vitaform, Vetaş Türkiye) were administered. Meloxicam (1 mg/kg, IM, q12h, ×2, Metacam 2%; Boehringer Ingelheim, Ingelheim, Germany) was used to manage pain.

Statistical Analysis

One-tailed bivariate Pearson correlations were used to compare predictors such as the cause of fracture, fracture location, fracture type, affected leg, age, and sex within treatment groups. The correlations among the predictors were also compared using Pearson correlation without grouping factors. The results of these comparisons were presented as *r* values. In addition, binary logistic regression analysis was performed to compare the predictors between groups. The results of this analysis were presented as odds ratios, *P* values from Fisher's exact test, and lower and upper confidence intervals (95%). Significance was determined by a *P* value of less than .05. All statistical analyses were conducted using the Statistical Package for Social Sciences version 22.0 software (IBM Corp.; Armonk, NY, USA).

RESULTS

A total of 24 budgerigars with TTFs were admitted to the animal hospital for treatment. Four birds were excluded from the study due to not meeting the inclusion criteria, resulting in a sample size of 20 birds. The treatments were administered using either a tape splint (n = 11, 55%) or IMEF surgery (n = 9, 45%). The success rate for the tape splint treatment was 9/11 (81.8%), while the success rate for the IMEF surgery was 6/9 (66.7%). Two patients in both groups experienced mild lameness after the 21st day of treatment. One bird died during surgery due to inadequate monitoring, and resuscitation efforts were unsuccessful.

Both the tape splint (7/11, 63.6%) and IMEF surgery (6/9, 66.7%) groups had a higher proportion of male Budgerigars. The ages of the birds ranged from 4 to 49 months (mean of 19.9 ± 11.9 months) in the tape splint group and from 6 to 48 months (mean of 18.22 ± 14.8 months) in the IMEF surgery group. The left leg was the most

Table 1. Correlation Table of Predictors Between Fracture Location and Cause of Fracture

	Fracture Location			
Cause of Fracture	Proximal	Media	Distal	Total
Door–window trauma	2	6	0	8
Unknown (in cage)	0	4	1	5
Entanglement into cage bars or tulle	0	1	4	5
Children	0	2	0	2
Total	2	13	5	20

There were intermediate bivariate correlations ($r = 0.6$) between fracture location and cause of fracture found ($P = .01$).

frequently affected in both groups (11/20, 55%). Midshaft fractures were common in both the tape splint (7/11, 63.6%) and IMEF surgery (6/9, 66.7%) groups. The most common fracture type in the tape splint group was transverse (8/11, 72.7%), while the most common type in the IMEF surgery group was oblique (5/9, 55.6%). The most common cause of fractures in the tape splint group was door–window trauma (4/11, 36.4%) or entanglement in cage bars or cage cover tulle (4/11, 36.4%). The most common cause of fractures in the IMEF surgery group was door–window trauma (4/9, 44.4%).

There was no significant difference between the 2 treatment methods (odds ratio: 0.44, 95% CI: 0.05-3.50, $P = .39$). A weak correlation was found between fracture location and fracture type ($r = 0.41$, $P < .03$). An intermediate correlation was observed between fracture location and the cause of fracture when the data was not grouped by treatment technique ($r = 0.64$, $P = .01$) (Table 1). A high correlation was found between fracture location and the cause of fracture within the tape splint group ($r = 0.94$, $P < .01$), and an intermediate correlation was observed between fracture location and fracture type in displaced fractures ($r = 0.73$, $P = .01$) (Table 2).

Orthogonal and oblique radiographs revealed apposition in all fractures, with better alignment in the IMEF surgery group. No signs of sclerosis or medullary canal radiodensities were observed on the 21st day radiographs of any patients during the healing process. The distribution of variables such as success rate of treatment method, cause of fracture, fracture location, fracture type, affected leg, age, and sex in the tape splint and IMEF surgery groups are presented in Table 2.

DISCUSSION

This study compared the effectiveness of tape splint and IMEF surgery for treating TTFs in budgerigars and found that IMEF surgery offers several advantages, such as rigid fixation, satisfactory alignment, and apposition. However, it is not a suitable primary fixation option for small birds due to the double risk of anesthesia (for pin replacement and removal), the lack of appropriate monitoring and implants in clinical settings, and the challenges of surgery in small avian patients.[15]

The IMEF surgery was developed as an alternative surgical method for providing rigid fixation of TTFs in budgerigars. To the authors' knowledge, there is limited clinical research on the use of tape splints or surgery for TTFs in budgerigars.

The tape splint method was found to be an easy and inexpensive method that allows fragments to stay together, requires fewer anesthetics, and has a success rate of 81.8% in nondisplaced TTFs in budgerigars. A previous clinical study reported a success rate of 92% for tibiotarsal external coaptation in companion birds.[2] While the tape splint provides satisfactory apposition, it may not provide the same level of alignment as the IMEF surgery. Poor alignment after external coaptation may result in malunion.[15] Orthogonal and oblique radiographs taken immediately postoperatively showed apposition of fractures in the IMEF group but not in the tape splint group. Although poor anatomic reconstruction due to inadequate fracture reduction was observed in patients treated with tape splints, budgerigars were found to tolerate this condition well without obvious lameness.

Surgical techniques are often necessary for proper alignment and apposition of primary bone healing.[4,8] While different surgical

Table 2. The Data of the Cases That Were Treated with Either Hybrid Intramedullary Pin with External Fixation Procedure (IMEF) or a Tape Splint

							Age (Months)		
Treatment, n = 20	Fracture Location	Affected Leg	Sex	Fracture Type	Outcome	Cause of Fracture	<12	12-24	> 12
IMEF surgery (9/20)	P	r	f	O	SR	DH	0	0	1
		l	m	O	SR	DH	1	0	0
	M	r	m	O	SR	DH	1	0	0
		r	m	O	X	CB	1	0	0
		l	m	O	SR	DH	1	0	0
		l	m	T	ML	N/A	0	1	0
		l	m	T	ML	C	1	0	0
		l	f	T	SR	C	0	0	1
	D	l	f	Sp	SR	N/A	1	0	0
Tape splint (11/20)	M	r	m	T	SR	DH	0	1	0
		r	m	T	ML	DH	1	0	0
		r	f	T	SR	CAT	1	0	0
		l	m	O	SR	N/A	0	0	1
		l	m	T	SR	DH	1	0	0
		l	m	T	SR	N/A	0	0	1
		l	f	T	SR	DH	0	1	0
	D	r	m	T	SR	CB	0	1	0
		r	m	T	ML	CB	0	1	0
		r	f	O	SR	CB	0	1	0
		l	f	O	SR	CB	0	1	0

C, children handling trauma; CAT, cat attack; CB, entanglement in the cage bars of cover tulle; D, distal; DH, door hit trauma; f, female; l, left; m, male; M, midshaft; ML, mild lameness; N/A, not answered; O, oblique; P, proximal; r, right; Sp, spiral; SR, successfully recovered; T, transverse; X, died.

techniques have been used to treat TTFs in large birds, not all of them are applicable to small birds.[16,17] There is no previously described surgical fixation method for TTFs in budgerigars, with the exception of one experimental study using intramedullary nailing.[8] The intramedullary nailing method lacks the ability to block rotational forces compared to IMEF surgery. The IMEF surgery can provide rotational and axial stabilization due to the polyaxial surfaces created between pin–bone contact points, percutaneous tapes, and the APEF exoskeleton configuration.

For the conventional tie-in fixation (TIF) configuration, 2 positive threaded-profile pins are placed in the proximolateral and distolateral aspects of the tibiotarsus, along with an intramedullary pin with a size up to 20% of the diameter of the tibiotarsus.[13] The small size of the bone and intramedullary canal limits the use of the TIF configuration in budgerigars. The main disadvantage of the IMEF surgery is that it involves the intraarticular involvement of both the stifle and hock joints, while the TIF technique only affects the stifle joint. The advantage of the conventional TIF technique is that it does not require the insertion of proximal and distal perpendicular pins on the bone axis.

There is limited literature on the use of external fixators for treating TTFs in budgerigars, but there are some reports in larger species. In raptors, the use of an external fixator for treating TTFs has been reported to have a success rate of 84%.[13] The success rate of IMEF surgery in budgerigars (66.7%) was lower than that of raptors. Raptors have a higher success rate than budgerigars because their bones are larger, making the approach easier.

Anesthesia and the challenges of monitoring small patients during surgery were identified as factors that contribute to the lower success rate of IMEF surgery in budgerigars.[18,19] Monitoring a budgerigar with devices is almost impossible due to its size; therefore, the most common method is observational monitoring during surgery. Additionally, monitoring may be complex for the operator if the patient is covered with surgical drapes. These factors negatively impact the success rate of surgery in budgerigars.

There are several causes of TTFs in budgerigars, including trauma from using doors and windows as perches, entanglement in cage wires or cover tulle, improper handling by children during play, and cat attacks. Predictors may lead to a fracture location on the tibiotarsus and may change the position of the fragments.[20]

Midshaft fractures were the most common location on the tibiotarsus in this study, as previously reported in other studies.[2,13] Budgerigars that used doors and windows as perches were more likely to have displaced fractures, likely due to the shearing force of the door or window closing and breaking the bone. Tibiotarsal fractures that were not displaced were more common in patients who became entangled in cage bars or cover tulle.

Oblique fractures were entirely displaced, possibly due to the fragments sliding over each other. Door, window, or cage-related fractures were the most common oblique fractures, likely due to the perpendicular force of the trauma shearing the bone axis. While psittacines tend to have midshaft and distal diaphyseal TTFs,[14] proximal fractures, particularly oblique and displaced ones, are common in budgerigars. The presence of sizable muscles around the proximal fragment, which can cause the fracture surfaces to slide over and collapse, may be the cause of the displacement of proximal oblique fractures.

Anesthesia-related death is a common occurrence in birds due to the lack of proper anesthetic and monitoring equipment.[4,5,14] While there were no complications observed in either treatment group except for one patient who died during surgery, the authors found that IMEF surgery presented more challenges due to anesthesia in budgerigars. These challenges included the lack of intubation and pulmonary resuscitation, the lack of intraoperative ECG monitoring, and the difficulty in approaching small birds. In situations where, appropriate equipment is not available, the use of a tape roll as an induction mask and a presterilized oven bag as a transparent surgical drape for patient monitoring may be helpful during surgery on small avian patients.

There are several limitations to this study. While the IMEF provides satisfactory fixation compared to the tape splint, the level of intraarticular damage to the hock and stifle joints was not evaluated. Additionally, the success rates of the IMEF surgery and tape splint methods were not statistically significantly different from each other, likely due to the small sample size.

In conclusion, the IMEF surgery may be considered an alternative treatment option for reducing displaced TTFs and providing rigid fixation, but the intraarticular involvement of both the hock and stifle joints should be considered when using this technique. Nonsurgical external coaptation with a tape splint, due to its ease of application, noninvasiveness, and lower anesthesia risk, should be considered the primary fixation technique for nondisplaced TTFs in budgerigars.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of the Atatürk University Local Ethics Council of Animal Experiments (HADYEK) (Date: 28.12.2021, Number: 2021/275).

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