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The Efficacy of Modified Transarticular External Skeletal Fixation Type II Technique for Management of Talocrural Instability in Dogs: Outcomes and Complications

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ABSTRACT

Objective: To report the efficacy of two approaches of modified type II transarticular external skeletal fixator (TESF) without joint arthrodesis for treatment of talocrural instability/luxation (TCI) in dogs and to rate short-term outcomes and complications after its use.

Study design: Retrospective study.

Sample population: Ten dogs.

Methods: Medical records of All dogs suffered from TCI and have been treated using TESF type II between January 2012 to December 2021 were reviewed. Information was collected including signalment, lameness score, type of TCI, accompanying injuries. The surgical management included TESF alone (n=2) and TESF with internal repair (n=8), both didn't involve debridement of the articular cartilage. The post-operative follow-up assessment included lameness score, ankylosis and complications.

Results: All dogs had satisfactory joint stability at the time of frame removal. All dogs exhibited minor complications, 4 dogs had major complications and persistent lameness. Females and older animals showed high degrees of joint ankylosis compared with males and younger animals.

Conclusion: Modified-TESF type II (with internal repair) technique would be better than arthrodesis. it is considered a joint saving procedure with high success rate regarding restoration of function, lameness score, ankylosis and short term postoperative follow up complications, Modified type II TESF with internal repair showed significant outcomes especially in heavy breeds dogs, preserving the articular cartilage reduces the overall complication rate and preserved the joint function.

Clinical significance: This study supports the use of temporary modified type II TESF with internal repair and without tarsal arthrodesis for management of TCI in dogs as an alternative to tarsal arthrodesis.

Keywords: Ankylosis, Dog, Instability, luxation, Talocrural and Modified transarticular external skeletal fixation type II.

INTRODUCTION

Canine tarsal is a vastly critical joint in terms of structural complexity (Piermattei et al., 2006), making diagnosis and management of its surgical affection is challenging (Deruddere et al., 2014), One of these affections is talocrural instability (TCI) which is traumatic in nature and as predominantly associated with malleolar fracture, collateral ligament tear and tissue deficit (Tobias et al., 2012, Aidar et al., 2018).

The frequency of traumatic TCI in dogs is reported to be up to 50% of traumatic joint luxation (Schaeffer et al., 1999, Aidar et al., 2018), which augmented by the scarcity of soft tissue support (Sjöström et al., 1994, Benson et al., 2002). On the other hand, biting is another important cause that terribly results in the shortfall of medial malleolus of the tibia and the breakup of the medial collateral ligament causing joint instability and disarticulation (Slocum, 2008).

Several surgical techniques were developed for management of TCI in small animals of which external fixator and tarsal arthrodesis were the means of choice in many situations (Mclennan, 2007, Roch et al., 2008, Aidar et al., 2018). Repair of the affected tarsal requires fitting both joint stabilities, its alignment, avoiding its further injury while asserting normal mobility range, and achieving early joint mobilization till healing of the articular cartilage surfaces and to avoid osteoarthritis (Bruce et al., 2002; Jaeger et al., 2005, Shearer, 2011). Moreover, the selected method should counteract the acting forces against the implant to avoid its failure (Clarke & Pink, 2013).

External fixator is useful for stabilization of the affected hock when skin is open. Moreover, it provides easy wound management, allows early weight-bearing, and provides satisfactory mechanical protection to affected joint (Jaeger et al., 2005). But the resultant ankylosis, pin loosing and pin tract infection are still the main complications associated with its use (Roch et al., 2008). On the other hand, arthrodesis of the tarsal joint has been used for management of TCI in small animals (Roch et al., 2008). However, it requires a second operation to harvest bone graft which may associate with pain, increased rate of infection and second site morbidity at that donor site (Newton, 1996, Muir and Norris, 1999, Rahal et al., 2006, Mclennan, 2007, Aidar et al., 2018). It is recommended by some authors as last solution for management of non-respond cases of TCI (Roch et al., 2008; Aidar et al., 2018).

However, there are a limited data about the most proper approach for handling TCI, this study aims to record the efficacy of modified trans-articular external skeletal fixation (TESF) type II technique for management of talocrural instability and set a guide for future studies relate to this condition in dogs and investigate the recorded measurements statistically to conclude the significant variances in treating this condition.

MATERIAL AND METHODS

Animals' data:

Data from records of ten dog that were referred to the clinic of small animal surgery, Justus Liebeg Universty at (JLU) Giessen, Germany, from January 2012 to December 2021 suffering from TCI were used. It included signalment (age, breed, sex, and body weight) (Table 1), cause of injury, extent of injury (ligament involvement and /or fracture of the malleoli).

Surgical technique:

All cases were treated with modified TESF type II as a primary tool for tarsal stabilization without articular cartilage involvement. It had been used as a sole treatment or accompanied with primary ligament suture, ligament prosthesis, lag screws or Kirschner wires. The animals were anesthetized according to the standard protocol used in the clinic. In which the animals were premedicated by intravenous injection (I/V) of methadone (Comfortan, Eurovet Animal Health B.V., AE Bladel, Nederland) at dose of 0.3 mg/kg and midazolam (Midazolam, hameln, Germany) at dose of 0.2 mg/kg. Anesthesia was induced by I/V injection of Propofol (Vetofol; Bayer Vital), 6mg/kg titrated to effect and maintained by Isoflurane (Isoflurane CP; CP-pharma) in 100 % oxygen at a flow rate of 1L/min. The area from the stifle to the fetlock was aseptically prepared and the animals were restrained in dorsal recumbency.

Lateral and /or medial skin incisions at the level of tarsal joint were performed as required for surgical repair of the affected ligament (suture or prosthesis) with or without internal fixation (K-wire or lag screw fixation). Collateral ligament suture was performed in a locking loop pattern using 2-0/3-0PDS. While Ligament prosthesis was performed via screws with washer technique in which two screws with washer were fixed at the talus and distal tibia respectively and were stabilized with Polyblend suture material *(Fiberwire, Arthrex, GmbH, Karlsfeld, Germany)* in a figure 8 pattern. K-wire or lag screws were inserted to fix the fractured malleoli (Fig.1). After insurance correct joint reduction, skin wound was closed and the luxated joint was stabilized using a modified type II TESF frame. Six or seven stab incisions were made, two at the tibia (the first at the proximal or middle third and the second one at the distal third), one at the calcaneus and three or four at the metatarsal bones (two at the lateral and one or two at medial aspect). Through each stab incision a positive profile threaded pin *(IMEX, Longview, Texas, United States)* was fixed to the bone. Center threaded pins (2.4-3.2 mm) were fixed to the tibia and the calcaneus while end threaded pins (1.6-2.4 mm) were used for the metatarsal bones where each pin fixed to four cortices (two adjacent metatarsal bones) (Fig. 2). The pins were bended at right angle, shortened then connected to each other by a bar of polymethyl methacrylate (PMMA) *(Technovit 3040, Kulzer Technique, Wehrheim, Germany)* at two cm from the skin surface (Fig. 3). The area between the skin and the PMMA bar was packed with sterile cotton and wrapped with adhesive tab (Fig.4). Strict rest was recommended in all cases until frame removal (6-8 weeks) (Hammer et al., 2020).

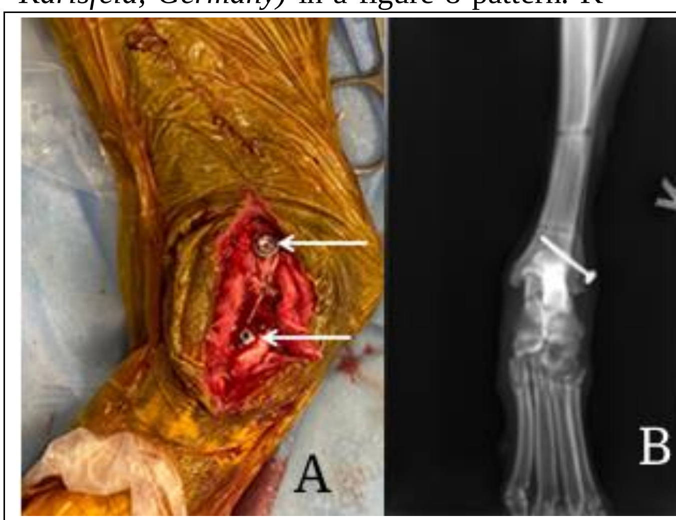

Fig 1: Ligament replacement by screws with 8 figure suture (A) and intraoperative dorso-planter radiograph showed placement of lag screw as

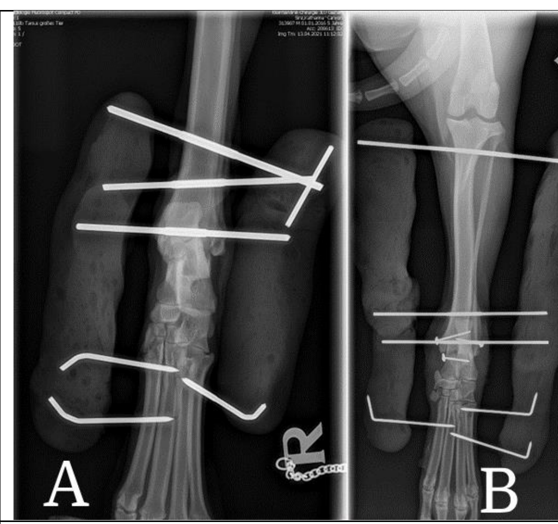

Fig 2: Postoperative dorso-planter radiograph showed modified type II TESF frame used alone (A), and in combination with screws for

prosthetic ligaments (B).	ligament replacement (B).
	
Fig.3: a bar of polymethyl methacrylate (PMMA), connecting the right-angled bended pins at two cm away from the skin surface	Fig.4: The area between the skin and the PMMA bar was packed with sterile cotton and wrapped with adhesive tab

Post-operative short-term follow-up:

The post-operative evaluation period was up to four weeks after frame removal. It included clinical evaluation, complications, and degree of joint ankylosis. Clinical evaluation included lameness degree, discharges at the site of pin. Complications were classified into minor complications that did not need added surgery and major complications that require added surgery, permanent unacceptable function, or animal death. The degree of tarsal ankylosis was evaluated for each joint separately (talocrural, intertarsal, tarsometatarsal joints) through the recheck radiograph and scored from 0 to 3 by two radiologists **(Fig. 5)**. Where 0= joint is entirely normal, 1= mild ankylosis in which there is mild narrowing of the joint space without new bone formation. 2 = presented moderate joint ankylosis in which there is moderate narrowing of the joint space with presence of small amount of new bone formation. 3= Complete ankylosis with complete fusion of the tarsal bones.

Fig.5: Radiograph of the tarsal joints showing different degrees of ankylosis at the tarsal joint; A), ankylosis of tarsometarsal joint, (B) ankylosis of intertarsal and tarsomettarsal joint and (C) complete ankylosis of tarsal joints.

Statistical analysis:

Statistical analysis was done via SAS software version 9.1.3 via Kruskal–Wallis one-way analysis of variance with Dunn–Bonferroni post hoc test. The results were considered significant different at $p < 0.05$.

RESULTS

Data of ten dogs suffering from TCI /luxation were included in this study is recorded in (Table 1).

Table (1): Animal's signalments at injury time:

No.	**Age (Months)**	**Sex**	**Breed**	**Body weight(kg)**	**Cause**
1	38	F	Labrador Retriever	24.5	car accident
2	80	F	Malinois	30	car accident
3	24	F	Rhodesian Ridgeback	33.3	bite
4	76	M	Border Collie	23.5	bite
5	40	M	Mischling	12.8	car accident

6	24	F	Weimaraner	26	car accident
7	40	F	Hovawart	36.5	car accident
8	28	M	Appenzeller Sennenhund	25	bite
9	101	F	Deutscher Jagdterrier	7.7	bite
10	56	M	Border colie	24.4	car accident

At the time of primary examination, the mean age of the dogs was 50 months (range from 24 to 101 months). According to the age distribution (Shearer, 2011), the included dogs werethree young adult (up to 3years old) and seven mature adult (older than three years) , four male and six female, the mean body weight was 24.3kg (range from 7.7 to 36.5 kg), no breed being overly represented. Car accidents were the main cause of TCI in six dogs, while bite was reported to be the cause in four dogs. Three dogs showed grade III lameness and seven dogs showed grade IV. Unilateral TCI was seen in five dogs (medial) and complete luxation in five dogs (Fig.6). Malleolar fracture has been recorded in six dogs; three dogs had a lateral malleolar fracture and three dogs had medial malleolar fracture. Collateral ligament rupture has been reported in nine dogs; eight dogs had medial, and one dog had bilateral collateral ligament rupture.

(Fig. 6) Dorso-planter radiograph showed **(A)** Medial talocrural instability with medial malleolar fracture, **(B)** Complete tarsocrural luxation with lateral malleolar fracture.

TESF was used alone in two dog cases one; had comminuted medial malleolar fracture and the other had comminuted medial malleolar fracture with medial collateral ligament rupture, both dogs had open skin. In the rest of the cases (eight dogs), TESF was used in combination with a lag screw or K-wire with ligament suture or ligament prosthesis (Fig. 1). Primary ligament suture was performed in six dogs. K-wire was used in one dog with medial malleolar fracture. Lag screw used in three dogs with lateral malleolar fracture. Ligament replacement with two screws and fiber wire suture was used in two dog cases (Table 2).

Table (2): Showing patient details, nature of tarsal injury, selected surgical technique and approaches.

Surgical technique (N)	**Number**	**Mean age body weight**	**Case description**	**Surgical approach**
TESF alone	Two	70 months (40-101) 22.1Kg (7.7-36.5)	- One dog had complete luxation with MMF. - One dog had Medial TCI with comminuted MMF &MCLR. - Skin perforation was present in two dogs	The frame was fixed without joint exposure. Skin wounds were treated to heal by second intention
TESF + primary ligament suture	Three	60 months (24-80) 26.5 Kg (23.5-30)	- One dog with complete luxation with MCLR and LCLR - Two dogs with medial TCL with MCLR - One dog with open skin and two cases with intact skin.	In case of complete luxation, the tarsal joints were exposed via lateral and medial skin incisions. While in cases of medial instability the tarsal joints were exposed via medial skin incision,
TESF + primary ligament suture + lag screw	Two	32month (24-40) 46.1 Kg (12.8-33.3)	- Two dogs had complete luxation accompanied with MCLR and LMF) - Skin was intact.	The tarsal joints were exposed via lateral and medial skin incisions.
TESF +K-wire	One	38 months 24.5 Kg	- - The dog had medial TCI with MCLR and MMF, the skin was open	The tarsal joint was exposed via medial incision
TESF + ligament replacement (screws with tigerwire)	One	56 months 24 Kg	- The dog had media TCI with MCLR with closed skin	The tarsal joint was exposed via medial skin incision.
TESF + ligament suture +	One	28 months	- The dog had complete luxation with MCLR and LMF with closed skin	The tarsal joint was exposed via lateral and medial skin

ligament replacement (screws with tigerwire)		25Kg		incisions.

Post-operative follows up:

Complications have been recorded in all (100%) dogs (Tables 3-5), (chart.1). Minor complications in terms of soft tissue swelling (n=5), pin tract infection (n=3), periosteal reaction around the pin entry (n=7), pin losing (n=3) were reported. While the reported major complications were pin broken (n=4) three cases treated by replacing the broken pins with new pins and one dog the broken pin was detected at the time of frame removal. PMMA bar broken (one dog) that treated by re-enhancement of the bar. At the end of the examination period the three dogs showed lameness grade I, one dog grade II and the rest of the cases had no lameness (Fig.7).

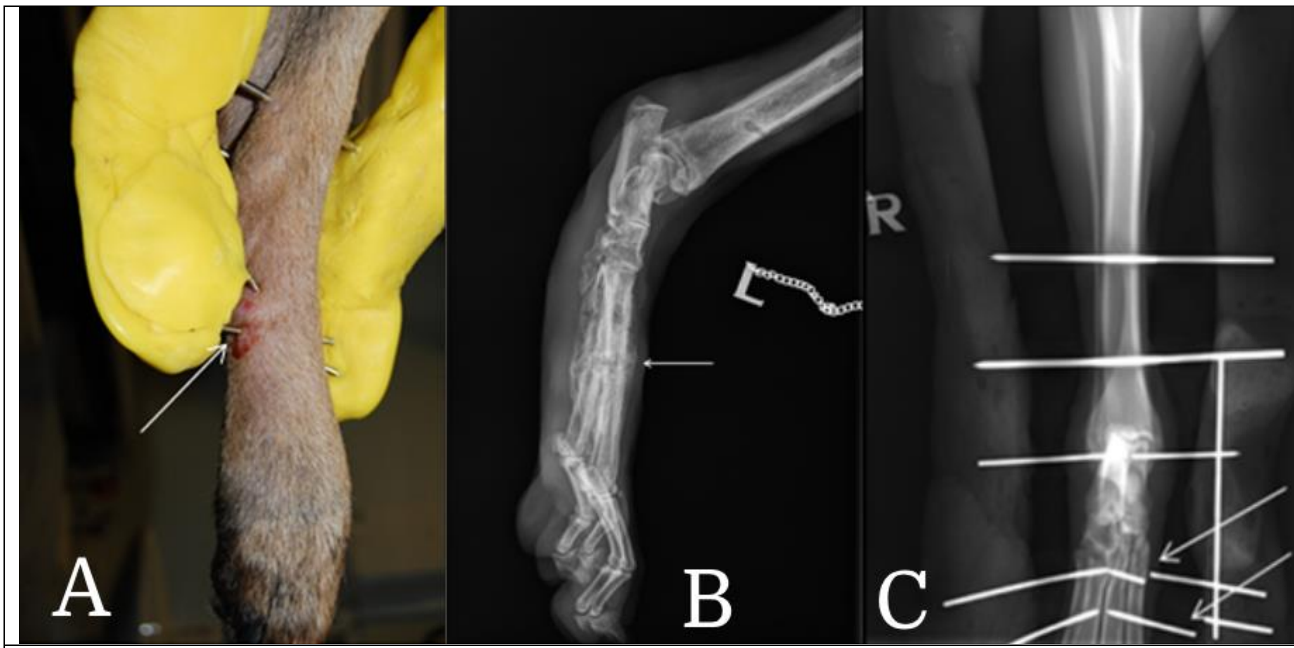

Fig.7: showing post operative complications (A): Pin tract infection, (B): Periosteal reaction and (C): Pin broken.

Statistical analysis:

Table (3). Effect of some physiological factors on preoperative and postoperative lameness score and postoperative joint ankylosis score in injured dogs.

Parameters	Classification	Postoperative **Lameness score**	Post treatment **joint ankylosis score**			
			tarsocrural	intertarsal	tarsometatarsal	Whole joint
Age	Less than 3 years	0.33±0.21	0.17±0.11	0.50±0.32	0.50±0.32	0.39±0.25
	More than 3 years	0.71±0.19	1.32±0.26 *	0.73±0.22	0.72±0.21	0.93±0.22

	Chi-square	1.10	2.25	0.71	0.71	1.5
	P-value	0.35	0.03	0.55	0.55	0.15
Weight	Less than 25 kg BW	0.99±0.17*	0.96±0.32	0.43±0.23	0.43±0.23	0.61±0.25
	More than 25 kg BW	0.00±0.00	1.00±0.30	1.00±0.23	1.00±0.23	1.00±0.22
	Chi-square	3.42	0.49	1.66	1.66	1.44
	P-value	0.00	0.86	0.14	1.14	0.18
Sex	Female	0.49±0.23	1.38±0.28 *	1.02±0.24 *	1.01±0.23*	1.14±0.22 *
	Male	0.75±0.16	0.38±0.25	0.13±0.08	0.13±0.08	0.21±0.14
	Chi-square	1.20	2.43	2.32	2.32	2.72
	P-value	0.31	0.02	0.03	0.03	0.01

0, 1, 2, and 3 scores denoted absence, mild, moderate, and severe degree of lameness, respectively. Values are presented as mean ± SE.

* Means of parameters within the same column are statistically differed at $p < 0.05$ (Mann-Whitney test).

0, 1, 2, and 3 scores denoted absence, mild, moderate, and severe joint ankylosis affections, respectively. Values are presented as mean ± SE.

* Means of parameters within the same column are statistically differed at $p < 0.05$ (Mann-Whetney test).

Table (4) Effect of different causes affections, involvement, and surgical treatments on preoperative and postoperative lameness score and post operative joint ankylosis score in injured dogs.

Parameters	Classification	Postoperative **Lameness score**	Post treatment **joint ankylosis score**			
			tarsocrural	Intertarsal	tarsometatarsal	Whole joint
Cause	Car accident	0.33±0.14	0.83±0.26	0.42±0.18	0.42±0.18	0.56±0.19
	Fight and bit	0.99±0.26	1.19±0.40	1.03±0.31	1.01±0.31	1.08±0.31
	Chi-square	2.05	0.81	1.82	1.82	1.12
	P-value	0.07	0.47	0.10	0.10	0.31
Affection	Affection 1	$0.50±0.19^{ab}$	0.75±0.28	$0.38±0.16^{b}$	$0.50±0.23^{b}$	0.54±0.22
	Affection 2	$1.95±0.05^{a}$	2.75±0.35	$2.10±0.10^{a}$	$2.05±0.05^{a}$	2.31±0.14
	Affection 3	$0.40±0.16^{b}$	0.80±0.27	$0.60±0.25^{ab}$	$0.50±0.21^{b}$	0.63±0.20
	Chi-square	6.45	5.77	6.05	5.96	5.62
	P-value	0.04	0.06	0.05	0.05	0.06
Involvement	Medial	0.40±0.16	1.00±0.28	0.50±0.21	0.50±0.21	0.67±0.21
	Complete	0.79±0.24	0.95±0.35	0.82±0.28	0.81±0.28	0.86±0.

						29
	Chi-square	1.17	0.16	0.98	0.97	0.16
	P-value	0.32	0.91	0.39	0.39	0.91
Surgical treatment	Treatment I (TESF alone)	0.98±0.56	2.40±0.24^{a}	1.80±0.18^{a}	1.53±0.30^{a}	1.90±0.24^{a}
	Treatment II (TESF with internal repair)	0.50±0.13	0.63±0.18^{b}	0.38±0.14^{b}	0.44±0.16^{b}	0.48±0.14^{b}
	Chi-square	0.84	3.17	3.05	2.44	3.13
	P-value	0.49	0.00	0.00	0.02	0.00

0, 1, 2, and 3 scores denoted absence, mild, moderate, and severe lameness affections, respectively. Values are presented as mean ± SE. a, b Means within the same column in affection parameter with different superscripts are statistically different at $p < 0.05$ (Kruskal–Wallis one-way analysis of variance with Dunn–Bonferroni post hoc test). Means of parameters within the same column are statistically differed at $p < 0.05$ (Mann-Whetney test).

0, 1, 2, and 3 scores denoted absence, mild, moderate, and severe joint ankylosis affections, respectively. Values are presented as mean ± SE. a, b Means within the same column in affection parameter with different superscripts are statistically different at $p < 0.05$ (Kruskal–Wallis one-way analysis of variance with Dunn–Bonferroni post hoc test). Means of other parameters are statistically differed at $p < 0.05$ (Mann-Whetney test).

Table (5). Effects of different treatments (TESF with internal repair and TESF alone) on the clinical signs of minor and major complications shown in injured dogs at the eighth day postoperative.

Clinical signs	N=10	**Minor complications**								Major complications			
		Soft tissue swelling		Periosteal reaction		Pin loosing		Pin track infection		Pin broken		Bar broken	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Treatment I (TESF alone)	2	1	50	2	100	1	50	1	50	0	0	0	0
Treatment II(TESF with internal repair)	8	4	50	5	63	2	25	2	25	4	50	1	13

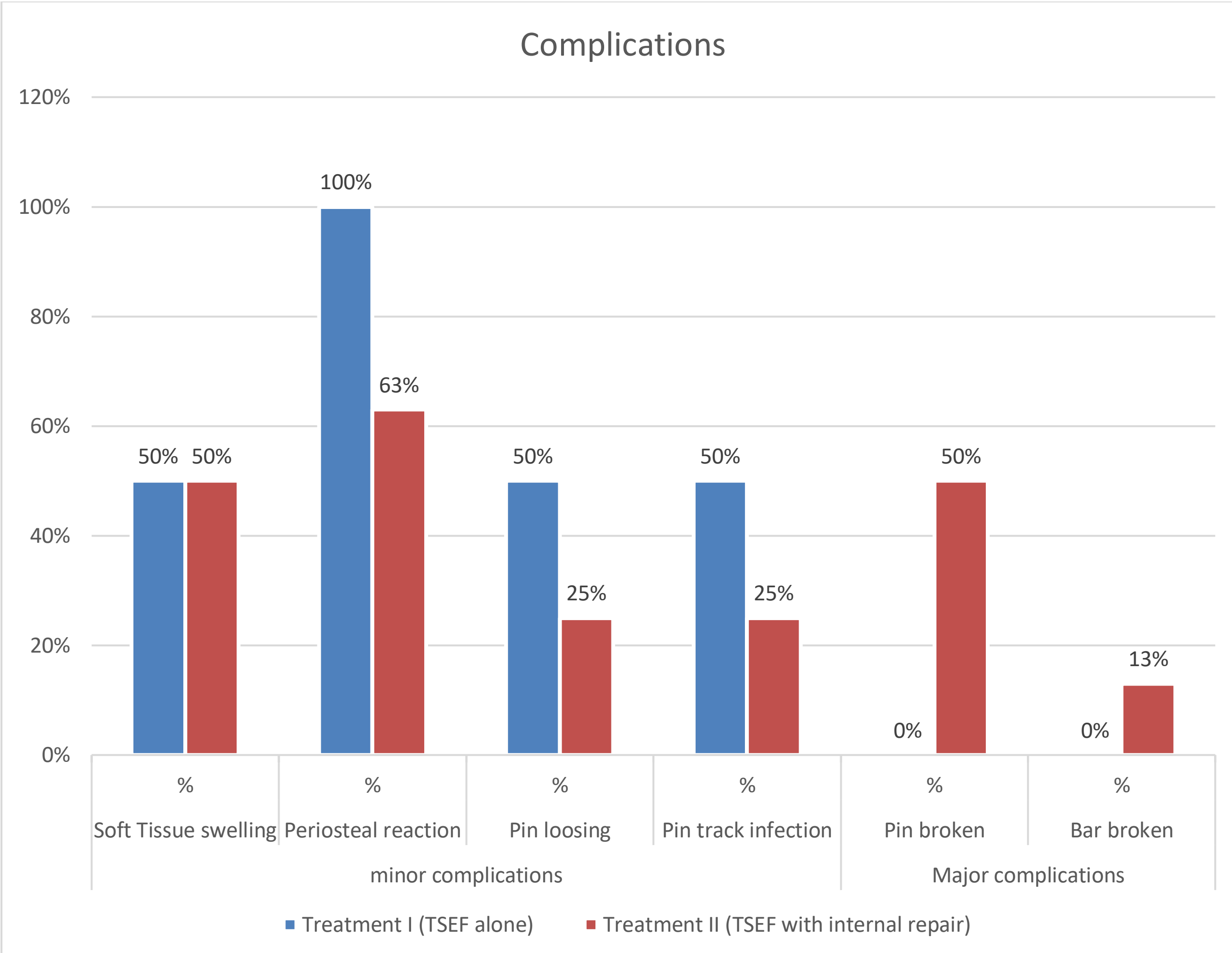

Chart (1): Effects of different treatments (TESF with internal repair and TESF alone) on the clinical signs of minor and major complications shown in injured dogs at the eighth day postoperative.

DISCUSSION

TCI in dogs is a critical condition affects dog tarsus. Tarsal arthrodesis was considered as treatment of choice (Rahal, 2006; Mclennan, 2007; Roch et al., 2008; Ayyappan et al., 2011; Aidar et al., 2018; Yardımcı et al., 2018). In this study, preservation of the articular cartilage and management of TCI in dogs using modified type II TESF have provided promising outcomes in terms of restoring of the function, short-term complication rates and the degree of tarsal ankylosis. In this study, sixty percent of dogs treated showed 0 score lameness with restoration of limb functionality in the examination period rather than other methods reported in previous studies (Fettig et al., 2002; Jaeger et al., 2005, Aidar et al., 2018)

Our reported data regarding animal's sex, age, body weight, affected limb, cause, and nature of joint injury found in accordance with some previous studies (Benson et al., 2002; Beever et al., 2016; Aidar et al., 2018). It was likely to be more in older animals; (younger than three years = 30%, older than three years = 70%), sex; (female = 60%, Male = 40%), causes were mainly traumatic in nature as reported by (Benson et al., 2002). However, (Mclennan, 2007) reported 100% in dogs younger than three years being 75% in males; and this is attributed to traumatic nature of the injury. No breed being overly represented.

Fighting (bite) and car accidents were 33%, 50% and 66%, 50% in females and males respectively. Car accident was the main cause in 33.3% right, 66% left, and it is mainly related to directional forces of trauma as reported (Aidar et al., 2018); however, in case of bite, it was 75% right, 25% left and, we assume that may be related to fighting conditions like size of fighting dog and the ease of attacking this side.

Our data showed that cases distribution as; cases were accompanied by ligament rupture (40%) and malleolar fracture alone (10%) and both ligament and malleolar fracture (50%). And for the right and left involvement of the limb (50% for each), the different condition of stabilizing structure beside which since the joint damage is evaluated intraoperatively ensure that This case considered challenging (Earley et al., 1980).

In 60 % of the affected cases TCI has been accompanied with malleolar fracture, while ligament rupture was reported in 90% of the treated animals. Which reflect the complexity of tarsal injuryand plays the major role in determination of the appropriate technique for joint stabilization and the concomitant complications (Earley et al., 1980, Piermattei et al., 2006).

Tarsal arthrodesis has been reported by many authors as the salvage treatment of TCI in many circumstances, its application is usually accompanied by several technical difficulties and complications (Shearer, 2011; Aidar et al., 2018). In this study, modified type II TESF has been used for temporary stabilization of the talocrural joint on its own or to protect other stabilization method such as internal fixation, ligament suture or replacement. In all treated cases the articular cartilage was preserved. Our goals were to minimally disrupt the traumatized tarsal joint, reduce the possibility of joint ankylosis and maintain normal joint movement to optimize outcome (Anderson et al., 1993; Jaeger et al., 2005; Ayyappan et al., 2011; Shearer, 2011).It is well documented that traumatic injury of tarsal joint is best managed first by reducing the luxation then constructed with external fixator for its benefice in terms of cost, simplicity, and stabilization as agreed by (Brinker et al., 1990)

In our approach the frame was mediolateral aligned rather than dorso-planter as in dorsal surface, it will face intensive flexing forces that lead to failure of the technique, although planter surface will inhibit tensile force but access to This site is very complicated due to neurovascular and tendinous structure (Pozzi et al., 2012), moreover medial access technique allows less damage to adjacent soft tissues, favouring the environment for bone proliferation (Mckee et al., 2004 and Guillou et al., 2008). Predrilled holes were drilled first then pins were inserted to maintain both thejoint proper angulation and stability to avoid failure as agreed with (DeCamp et al., 2016; Aidar et al., 2018)

Compared to plate arthrodesis technique, the used technique in this study has the advantage of being simple, less soft tissue dissection, no involvement of bulky implants that interfere skin closure. Moreover, it overcomes the disadvantages of plate arthrodesis in which application of the plateis based on the functional angulation of the tibiotarsal joint of the contralateral limb (Muir and Norris, 1999, Aidar et al., 2018). As well as a second operation is required for plate removal (Newton, 1996).

In the present study, the number of the used pins was two at the tibia, one at the calcaneus, and 3-4 at the metatarsal bones. In author opinion, the used number and distribution of fixation pins provided adequate stabilization while no implant related problems have been reported comparing to previous by Kulendra et al. (2011), Hammer et al. (2020) & Moon et al. (2020). In our study 2 pins were fixed to the tibia, which was satisfactory, provided adequate stability, and didn't interfere with animal movement. This was found in contrast with previous study by (Kulendra et al., 2011), in which the use of a minimum three pins above and blew the tarsal joint have been recommended by the authors to reduce the rate of implant-related complications. Moreover, the use of calcaneus as a fixation point in this study is very important from our point of view, which is necessary to avoid joint rotation and eliminated the need for the use of additional pin through the body of the talus (Mclennan, 2007).

In this study, the connecting bar formed from polymethyl methacrylate which is superior to the traditional calp-and-rod system that has been used in previous studies in terms of the highest fixation strength in flexural test by (Takahashi et al., 2017), the traditional calp-and-rod system has several disadvantages including difficulty of post-operative radiographic assessment, its overweight and unwieldiness. On the other hand, the used polymethyl methacrylate connecting bars can be easily reconfigured, light, facilitated the use of different pin sizes, and radiolucent allowing radiographic evaluation (De La Puerta et al., 2008).

In this study TESF has been used alone for management of TCI in two dogs. Also in previous reports, the authors used the frame alone to provide sufficient joint stabilization until complete healing of the periarticular tissues with fibrous tissue formation (Meeson & Davidson, 2011; Beever et al., 2016; Moon et al., 2020). In other cases, the frame was used in combination with internal fixation devices and/or ligament suture or protheses. It has been stated that primary collateral ligament prosthesis or suture should be achieved to maintain the range of motion during stabilization, when instability was attributable to ligament damage (Beever et al. 2016).

According to our results animal's age and sex have a significant impact on postoperative joint ankylosis. A high degree of tarsal ankylosis was reported in females and older dogs comparing to males and younger ones. In previous reports by (Brunnberg, 2003; Shani & Yeshurun, 2006), the authors attributed ankylosis of the tarsal joint to immobilization of the joint and periarticular fibrosis resulting in fusion of low-motion tarsal joints with subsequent intraarticular adhesions and atrophy of articular cartilage. For this they recommended physiotherapy and early joint mobilization to reduce the overall poor postoperative outcome. On the other hand, animals that have been treated with TESF alone showed a high degree of ankylosis compared to other cases. By reviewing medical records of both animals, it was noticed that both animals suffered from TCI accompanied with malleolar fracture. Therefore, it can be assumed that the reported high degree of ankylosis occurred because of excessive bone reaction due to instability of the fractured bone fragments. From the above-mentioned, it can be stated that, when malleolar fractures exist, its fixation becomes a critical need.

Six to eight weeks of fixation appeared to be sufficient period for healing of the affected joints. During this period the fractured malleoli completely healed as well as the injured periarticular tissues formed fibrous tissue adequately strong to fully support the joint. These results match previous reports by Schmokel & Ehrismann, (2001), Jaeger et al. (2005) & Hammer et al. (2020), in which the authors reported that three to six weeks is a sufficient period for complete healing of the affected joint. They also do not recommend a long period of rigid fixation because it may lead to degeneration of the articular cartilage.

Although all treated animals showed a high degree of lameness (Schmokel & Ehrismann, 2001; Jaeger et al., 2005; Beever et al., 2016; Hammer et al., 2020), a significant relationship between weight and improvement of lameness score. Animals over 25Kg showed better improvement than those less than 25 kg body weight by the end of the observation period. In the author's opinion, this may be attributed to breed variation. Although study of this factor not included in our study, however this is considered a valuable result for treating the condition in heavy breeds dogs.

In this study although the proportion of minor complications was high (100%), major complication was reported only in 40% (4 of 10) of the treated dogs which are fixator associated. This result was found in accordance with (Beever et al., 2016). All reported minor complications werecontrollable after frame removal and didn't require additional surgical interference (Beever et al., 2016; Moon et al., 2020). Moreover, the reported major complications were confined to pin broken that was easily to correct by pin replacement.

The major limitations of this study include its retrospective nature. The low number of cases. Lacks long-term follow-up evaluation. No breed impact involved in statistics.The lack of objective gait evaluation represents another limitation. In conclusion, our study confirmed that usage of Modified-TESF type II (with internal repair) technique would be better than arthrodesis, it is considered a joint saving procedure with high success rate regarding restoration of function, lameness score, ankylosis and short term postoperative follow up complications, however the stabilizing structure and the number of bins used with frame in the modified technique should be based on animal body weight and age rather than surgeon preference or decision.

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CONFLICT OF INTEREST

Authors declare no conflicts f interest related to this report.

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