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Cost-effectiveness of pin-in-fibreglass cast versus Kirschner-Ehmer type I external skeletal fixator in the management of transverse radius-ulna fractures in dogs

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Abstract

The cost of medical care is an important issue all over the world. With worsening global economy and the poverty inherent in low earning economies in the third world countries, economic considerations have always remained a major determinant factor in the choice of treatment. In this study, the cost-effectiveness of pin-in-fibreglass cast fixator (PFCF) was comparatively evaluated against a commercially available fixator (Kirschner-Ehmer type I external fixator) (KESF) in the management of induced closed transverse mid-shaft radius-ulna fractures in dogs. Four adult (2 males and 2 females) dogs with closed transverse mid-shaft radius-ulna fractures were used for this study. These dogs were randomly assigned to two groups (A and B) with each group made up of two dogs. Radius-ulna fractures were created in all the dogs under injectable anaesthesia as follows: Group A; PFCF, and Group B; KESF. A cost analysis was performed using the duration of operative and post-operative procedures, duration of morbidity period, direct and indirect labour cost, and cost of dog-hour lost during the morbidity period as economic indices. The overall duration of the operative and the entire post-operative procedures were 5.5±0.14 and 22±0.21 hours (1:4.4) for PFCF and KESF ($P>0.05$) respectively. The morbidity period was 9 and 8 weeks for PFCF and KESF respectively. The average cost of medical care (in 2015 $1 US ≈ N198 Nigerian Naira) was $81.8 and $294 (1:3.6) for PFCF and KESF respectively. The cost benefit analysis based on the economic loss due to dog-hour lost during the morbidity period were $990. 9 and $1103 (1:1.1) for PFCF and KESF respectively. In conclusion, PFCF is faster and easier to perform, and more economical than the KESF technique despite the longer morbidity period associated with it. This is accounted for by the lower cost of fixative and hospital charges.

Keywords: Dog, Cost effectiveness, Pin-in-fiberglass cast, Kirschner-Ehmer external fixative, Radius-ulna, fractures

Introduction

Over the past two decades, there has been a global paradigm shift from more invasive to less invasive approach for long-bone fracture reduction and many treatment modalities have been proposed for fractures such as those of the radius and ulna bones (Matthew & Kenneth, 2008). Fractures of the radius

and ulna are one of the commonest fractures in dogs which comprise about 17% of the fractures seen in small animal practice (Greg, 2003). Closed reduction technique such as external coaptation alone has resulted in more complications and delayed healing of these fractures (Hassan & Hassan, 2003), therefore, modern external fixatives are needed (Carmichael, 1991). Various methods have been used in the management of radius and ulna fractures; however, external fixation methods are primarily suggested (Charles & David, 1985). Although, the use of simple external fixations are becoming more and more popular for the treatment of fractures in animals, their potentials have not been fully maximized due to the fact that the current commercially available external fixation devices are complex and expensive (Goh *et al.,* 1997, Bada *et al.*, 2017). The cost of treatment and medical care is an important issue all over the world (Emara *et al.*, 2015). Furthermore, with worsening global economy and the poverty inherent in low earning economies in the third world countries, economic considerations have always remained a major determinant factor in the choice of treatment (Onche & Igo, 2005). Not only the cost of surgery, wound dressing, physiotherapy etc. is of utmost concern to pet owners (Emara *et al.,* 2015), there is also the economic burden on the dog owners due to days of absence from work of their dogs (e.g breeding stud, sniffer dogs, and guard dogs). Cost analytical studies of various surgery treatment modalities in humans have been published by several researchers (Buechsenschuetz *et al.*, 2002; Onche & Igo, 2005; Emara *et al.*, 2015). They documented that the most important factors contributing to the cost of treatment were the cost of surgical implants, instruments, and duration of treatments, which have been reported to be significantly higher in operative than conservative managements.

Cost analytical studies of treatment in dogs in Nigeria have not been fully documented in comparing the cost of various treatment modalities for radius-ulna fractures in dogs. There is an increasing number of automobile accidents which maybe associated to non-enforced leash law in several countries including Nigeria (Emmanuel, 2010). Thus, there is need to investigate on the relatively cheaper and technically less tedious and cumbersome ways of managing fractures sustained from accidents or otherwise. This study is therefore intended to comparatively evaluate the cost-effectiveness of pin-in-fiberglass cast fixator versus a commercially available fixator (Kirschner-Ehmer type I external fixator) in the management of radius-ulna fractures in dogs using criteria such as operative and post-operative care time, clinical and surgical cost, the cost of absence from work (dog-hours loss) in order to define the appropriate technique that would be most cost effective for the pet and the pet owners.

Materials and Methods

Experimental design

The conduct of this research was approved by the Ethical Committee on Animal Use and Care of Ahmadu Bello University, Zaria with reference number ABUCAUC/2016/031. It was conducted in the Department of Veterinary Surgery and Radiology, Ahmadu Bello University, Zaria. Nigeria. Four adult Nigerian indigenous dogs (10.13±0. 9 Kg) of different sexes (2 males and 2 females) with experimentally created closed midshaft transverse radio-ulna fractures were used for this study. The animals were randomly assigned into two groups (A and B) with each group comprising of two dogs (a male and a female). Group A dogs underwent pin-in-fiberglass cast technique while group B dogs underwent Kirschner-Ehmer type I external skeletal fixation technique for the repair of the closed, mid-shaft transverse radius-ulna fractures under general anaesthesia (thiopental sodium (10-20 mg/kg) for induction and ketamine hydrochloride (11-22 mg/kg) for maintenance). The pin-in-fiberglass cast fracture reduction technique for group A dogs was performed as described by Bada *et al.* (2017) (Plate I). This was carried out by drilling two threaded positive profile transfixation pins each cranio-caudally into the proximal and distal fracture segments of the fractured radius-ulna bones to exit the skin at the opposite side. Orthopedic cast padding fenestrating the protruding transfixation pins was then applied in a double thickness which was overlaid with Fiberglass cast material (Perfect Cast® Hospital and Home Care UK) incorporating the protruding transfixation pins until the whole length of the pins were covered by the cast. The cast extended from the level of the radial head proximally to the level of the radial and ulnar styloid process distally. The type I external skeletal fixation (Asco stainless steel, India) for group B was carried out as described by Permattei *et al.* (2006) (Plate II).

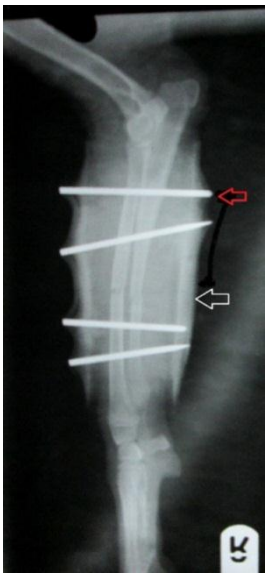

Plate I: Lateral radiograph of radius-ulna fractures managed with pin-in-fibreglass technique. Circumferential fibreglass cast (white arrow); through and through transfixation pins (red arrow)

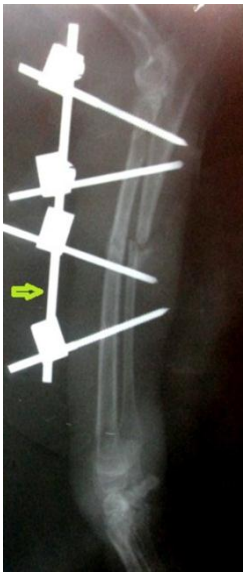

Plate II: Lateral radiograph of radius-ulna fractures managed with Kirschner-Ehmer type I external fixation, Green arrow indicate type I external skeletal fixator

Duration of operative and post-operative procedures

The operative and post-operative care time for the two techniques were determined. The operative time was determined by measuring the time from first transfixation pin insertion to when the application of the fixative and dressing was completed. The post-operative care time was determined by measuring the time needed to conduct daily post-operative check-ups on the dogs which included; assessment of fixative, daily cleaning of pin-skin interface and dressing, antibiotic and analgesic administration, assessment and management of complications, period of controlled exercise, and physiotherapy (Coyte *et al.*, 1997).

Economic implication

The cost implications of carrying out the two techniques were evaluated. All relevant direct cost categories were identified and measured. The direct costs included the cost of treatment, labour, equipment, anaesthesia, analgesia, radiography, antibiotics and other consumables. Indirect costs which included the cost of treating complications were also estimated. The cost boundaries adopted in the economic analysis for this study was that of the Veterinary Teaching Hospital, Ahmadu Bello University, Zaria. The cost-benefit analysis based on dog-hour lost during the morbidity (healing) period was also evaluated. This analysis was carried out using performing dogs for which breeding stud which is a popular commercial use of dogs in our locality was used as a case study. This was calculated based on the loss that would be incurred by the breeder (owner of the stud) weekly during the morbidity period that his dog is out of business. The cost boundary adopted for the weekly income earnings of breeder per breeding stud was based on the survey we carried out among dog breeders in Zaria, Kaduna State, Nigeria. All the surgical procedures were performed by the same surgeon. The currency used for the study was the United States Dollars ($US) (In 2015 $1 US ≈ N198 Nigerian Naira) (CBN, 2015)

Data analysis

Continuous variables were presented as means with standard deviations (Mean ± SD). Mann-Whitney test was used to test for statistical significance between test groups using SPSS version 13.0 for windows.

Results

Duration of Operative and Post-operative Procedures

The mean operative and post-operative care time for the two techniques in the management of radius-ulna fractures is shown in Table 1. The study showed that mean operative time required for performing the two techniques were 1.75 ± 0.06 hours and 2.5 ± 0.07 hours ($p>0.05$) for the pin-in-fiberglass cast and Kirschner-Ehmer external fixation respectively. While it required 3.75±0.14, and 19.5±0.07 hours ($p>0.05$) on the overall to perform post-operative care for

pin-in-fiberglass and Kirschner-Ehmer external fixation techniques respectively from the time of post-operative recovery to patient discharge after fracture union. The mean total management time were 5.5 ± 0.19 hours and 22 ± 0.36 hours ($p>0.05$) for pin-in-fiberglass and Kirschner-Ehmer external fixation techniques respectively.

Economic implication

The average cost implication of carrying out the two techniques in a dog with radius-ulna fractures is as shown in Table 2. The costs were $81.8 and $294 (1:3.6) for pin-in-fiberglass casting and Kirschner-Ehmer external fixation respectively. The cost-benefit analysis of managing radius-ulna fractures in a breeding stud is as shown in table 3. The total loss that would be incurred by the breeder per stud (owner of the stud) during the morbidity period (dog-hour lost) was $990 and $1103 (1:1.1) for pin-in-fiberglass casting (with morbidity period of 9 weeks) and Kirschner- Ehmer external fixation (with morbidity period of 8 weeks) techniques respectively.

Discussion

Globally, the cost of medical care is an important issue (Emara *et al.*, 2015). For the human patients, health authorities and insurance system keep asking the medical community about the cost effectiveness of different medical and surgical procedures (Dall *et al.*, 2013). Same can also be said in veterinary practice as animal owners are very mindful of the cost effectiveness of medical and surgical procedures. However, the choice of treatment needs to give a good clinical outcome and earlier return to function with least burden on medical service (Gil *et al.*, 2013).

Table 1: Mean operative and post-operative time analysis for pin-in-fibreglass cast (Group A), and Kirschner-Ehmer external fixation (Group B) techniques in the management of radius-ulna fractures (Mean ±SD)

	Group A (n=2)	Group B (n=2)
Operative time (OT)(hrs)	1.75 ± 0.06	2.5 ± 0.07.
Post-operative care time/days (POD) (hrs)	0.25 ± 0.05	0.5 ± 0.15
Number of Post-operative care days (NPD) (days)	15 ± 2.0	39 ± 1.0
Total post-operative care time (TPT)= (POD x NPD) (hrs)	3.75 ± 0.14	19.5 ± 0.07
Total management time TMT= (OT + TPT)(hrs)	5.5 ± 0.19	22 ± 0.36
Ratio	1	4.4

Table 2: Average cost analysis of radius-ulna fractures managed with pin-in-fibreglass cast, (Group A), and Kirschner- Ehmer external fixation (Group B) in a dog, ($US)

Consumables	Average cost/dog	
	Group A	Group B
Anaesthesia	6.3	6.6
Radiography (AP & lateral)	18.2	15.2
Analgesia	1	1
Antibiotics	1	1
Bandaging materials	2.7	17.6
Kirschner-Ehmer external fixator	-	151.5
Fibreglass cast	17.2	0
Steinman pins	10	0
Elizabethan collar	0	1
Net Total	56.6	193
Service charge	25.2	101
Grand Total	81.8	294
Ratio	1	3.6

Table 3: Cost-benefit analysis of radius-ulna fractures management in a breeding stud with pin-in-fiberglass casting (Group A), and Kirschner- Ehmer external fixation (Group B) ($US)

	Group A	Group B
Income /Week by breeder (IPW)/dog	101	101
Loss incurred by breeder/Week/dog during morbidity period (LMP)	101	101
Morbidity period (MP)/dog	9 Weeks	8 Weeks
Loss incurred during morbidity period by breeder/dog (LMP)= (LMP X MP)	909	808
Cost of fracture treatment (CFT)/dog	81.8	294
Profit-loss (LMP + CFT)/dog	990	1103
Ratio	1	1.1

We have found no other reports on surgical cost-effectiveness of radius-ulna management in dogs. The advantages of surgical cost measurement includes the ability to compare directly the cost-effectiveness of various interventions across different patient populations (Bhandari *et al.*, 2004). In this study, two techniques were economically evaluated for the management of closed transverse midshaft radius-ulna fractures in dogs. The overall time required for operative and post-operative care for the two surgical techniques in the repair of radius-ulna fractures revealed that the pin-in-fiberglass cast technique was less time consuming than the Kirschner-Ehmer external fixation technique. External skeletal fixation is a highly versatile and effective treatment modality, but it requires high technicalities and experience in application and also diligent care during the convalescent period (Carmichael, 1991; Permattei *et al.,* 2006). Animal owners are usually given some series of routine instructions on fixative care (Permattei *et al.*, 2006). Such routines include; daily inspection of apparatus for loosening, daily cleaning of crust and exudate around the pins, treatment of the pin sites with a topical antibiotic medicine, and a dressing to cover the splint, were also undertaken in this study. Hence, the longer man-hour required for this technique. In the pin-in-fiberglass cast group however, the aftercare needed for the fixative device was simple and minimal as it did not need much close monitoring. The pin-skin interfaces were well covered by povidone iodine soaked gauze wrapped around each pin hole and also the overlaid cast padding which provided a good cover against microbial invasion. The development of cast sores around the proximal edge of the cast was the only time that much attention was needed by the dogs in this group.

The operative and post-operative management cost analysis of the two techniques evaluated in this study revealed that the management of radius-ulna fractures with pin-in-fiberglass cast was more economical than using Kirschner-Ehmer external fixative. The higher cost of the Kirschner-Ehmer external fixative technique was majorly due to the high cost of the fixative and the service charge. Even though it may be argued that the Kirschner-Ehmer external fixatives are reusable, the potential savings of such a program is 25% of the cost of new frames (Sung *et al.*, 2008). This, therefore, means that a Kirschner-Ehmer external fixative intended for reuse will cost $113.6 instead of $151.5 for a brand new one which may still be beyond the reach of clients in our environment. It is also good to know that the Steinman transfixation pins used in the pin-in-fiberglass fixative technique are also reusable. The unavailability of these Kirschner-Ehmer external fixatives is a serious challenge to a surgeon as was encountered in this study as they are not available locally because most surgical equipment sales outlets do not keep such on their shelves due to their high cost and low patronage either by the human or the veterinary surgeons. Their high initial cost could also make it difficult for young practicing veterinary surgeons to add them to their arsenal of surgical equipment. Also based on our experience in clinical practice, the uncooperative attitude of some pet owners may get to an extent in which clients disappear with their pets or sold their pet off while a surgical implant which is implanted for fracture repair is still in the dog. Such experience may make a young veterinary surgeon reluctant to invest his/her hard earned money into purchasing and using such expensive device.

The cost-benefit analysis based on the cost of dog-hours lost during morbidity period in a high performing dog like a breeding stud also favours the

pin-in-fiberglass cast technique. Even though the Kirschner-Ehmer external fixation group had a shorter morbidity period (eight weeks) when compared to the pin-in-fiberglass cast group (nine weeks), the higher surgical cost of the Kirschner-Ehmer external fixation technique made it to have a lower cost-benefit ratio thus making the pin-in-fiberglass cast technique to offer a more economical sense to pet owners.

Therefore it was concluded that the treatment of simple radius-ulna fractures with pin-in-fiberglass cast is more cost effective than the Kirschner-Ehmer external fixation and allow earlier return to function.

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