

Observational Study

Cost of external fixation vs external fixation then nailing in bone infection

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school or work were calculated and compared between both groups.

RESULTS: The cost of hospital stay and surgery in the group of external fixation only was 22.6 ± 3.3 while the cost of hospital stay and surgery in the group of early external fixation removal and replacement by intramedullary nail was 26.0 ± 3.2 . The difference was statistically significant regarding the cost of hospital stay and surgery in favor of the group of external fixation only. The total cost of medical care (surgery, hospital stay, treatment outside the hospital including medications, dressing, physical therapy, outpatient laboratory work, etc.) in group of external fixation only was 63.3 ± 15.1 , and total absence from work was 38.6 ± 6.6 wk. While the group of early removal of external fixation and replacement by IM nail, total cost of medical care was 38.3 ± 6.4 and total absence from work or school was 22.7 ± 4.1 . The difference was statistically significant regarding the total cost and absence from work in favor of the group of early removal and replacement by IM nail.

CONCLUSION: Early removal of external fixation and replacement by intramedullary nail in treatment of infected nonunion showed more cost effectiveness. Orthopaedic society needs to show the cost effectiveness of different procedures to the community, insurance, and health authorities.

Key words: Cost; Fixator; Nailing; Infection

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Abstract

AIM: To study the cost benefit of external fixation vs external fixation then nailing in treatment of bone infection by segment transfer.

METHODS: Out of 71 patients with infected nonunion tibia treated between 2003 and 2006, 50 patients fitted the inclusion criteria (26 patients were treated by external fixation only, and 24 patients were treated by external fixation early removal after segment transfer and replacement by internal fixation). Cost of inpatient treatment, total cost of inpatient and outpatient treatment till full healing, and the weeks of absence from

Core tip: Fifty patients with infected nonunion tibia (26 patients were treated by external fixation only, and 24 patients were treated by external fixation early removal after segment transfer and replacement by internal fixation). Cost of inpatient treatment, total cost of inpatient and outpatient treatment till full healing, and the weeks of absence from school or work were calculated and compared between both groups.

Early removal of external fixation and replacement by intramedullary nail in treatment of infected nonunion showed more cost effectiveness. Orthopaedic society needs to show the cost effectiveness of different procedures to the community, insurance and health authorities.

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INTRODUCTION

Chronic bone infection can be secondary to open fracture, or post-operative^[1]. Treatment of infection requires radical debridement, bone stability, and reconstruction of the bone defect resulted from debridement or nonunion^[2]. Ilizarov technique is one of the most effective techniques used in bone infection: for stabilization, limb reconstruction, and fracture healing^[3].

Ilizarov technique and external fixation system has many advantages including versatility, and high success rate in treatment of bone deformity, and infection^[4]. But the long duration of external fixation is associated with many complications including: pin tract infection, joint stiffness, disuse atrophy, psychological stress, long duration of absence from work, and many other complications^[5].

There are several surgical techniques proposed to shorten the duration of external fixation in treatment of bone infection. That includes lengthening then nailing technique^[6], and lengthening over nail^[7], and hemicorticotomy^[8], and many other techniques. On the other hand there are several biological techniques proposed to shorten duration of external fixation: for example early bone graft for the docking site^[9], platelet rich plasma^[10], bone marrow injection^[11], and many other techniques.

The cost of treatment and medical care is an important issue all over the world, not only in poor countries^[12]. This cost puts a huge burden on the financial, insurance and health authorities and also affect the productivity of the community^[13,14]. The cost in treatment of bone infection is not only the direct hospital cost of multiple surgeries. Not only the cost of care required at home including wound dressing, physical therapy, *etc.* There is the economic burden on the patient family, and community due to days of absence from work or school^[15,16].

There are not so many papers in the scientific orthopaedic literature deal with the cost effectiveness of different surgical techniques^[17]. This study presents two techniques used in treatment of chronic bone infection and nonunion. Both techniques involve segment transfer by Ilizarov external fixation. In one technique the external fixation is removed early after eradication of infection

and finishing segment transfer, and replaced by intramedullary nail^[18-20]. The other technique is to continue with external fixation till full healing of the fracture, docking site, and distraction callus^[21-23]. Both techniques showed comparable long term outcome^[18].

The aim of the study is to compare the cost of the two different techniques including hospital and surgical cost, home care cost, and absence from work or school, and to define which would be more cost effective for the patient and the community.

MATERIALS AND METHODS

This is a retrospective study included 71 patients treated for infected nonunion tibia after open fracture, between 2003 and 2006. All cases were classified as type B 1 according to Paley *et al*^[24] classification for nonunion (defect more than 1 centimeter after debridement with no leg shortening). Average duration of nonunion and infection was 13.4 mo (ranged between 9-27 mo). Age ranged between 19 and 45 years old. Out of the 71 patients 39 were treated by external fixation only till full fracture healing, while 32 patients were treated by external fixation at the early stages till segment transfer was finished then external fixation was removed and replaced by intramedullary nail.

Inclusion criteria in this study were infected nonunion fracture tibia, treated by Ilizarov technique, with follow-up more than 2 years. Cases excluded from statistical analysis were patients who needed unexpected surgery for complications, cases of more than one fracture and patients without enough information about the cost and bills of medical care inside and outside the hospital.

After the use of these inclusion and exclusion criteria 21 patients were excluded from statistical analysis. The group of external fixation only included 26 patients (25 male and one female). The group of external fixation then nailing included 24 patients (22 male and 2 female).

Technique

Patients with infected nonunion fracture shaft tibia. Surgical debridement resulted in a bone defect ranged between 3-5 centimeters. Application of Ilizarov external fixation system and corticotomy was done. After surgery post-operative regimen during the first 45-75 d included: follow-up of the wound, pin care, antibiotics according to culture and sensitivity, and segment transfer to reconstruct the bone defect start 10 to 14 d after surgery. Laboratory follow-up of all patients every 2 wk during this stage for decreasing erythrocyte sedimentation rate and C-reactive protein beside wound condition to ensure eradication of infection^[25].

At this stage (45-75 d after first surgery) choices were given to patients including benefits and risks. One choice is to continue with external fixation till full fracture healing and consolidation of the distraction callus. This choice has the advantage of being safe with no need for another major surgery and less risk for recurrence of infection and this technique is classic and many literatures explained the long term outcome of this technique. But

the disadvantage is the longer duration of external fixation with more risk of pin tract infection, and joint stiffness, discomfort, and other complications of long duration of external fixation^[18]. Patients who chosen this line of treatment had autogenous bone graft surgery at the docking site to avoid slow healing of the docking site with no internal fixation and continued with external fixation till full healing^[21].

The other choice was removal of external fixation and replacement by intramedullary nail. The advantage of this choice is more comfort to the patient and easier physical therapy to regain range of movement and muscle strength. Disadvantage included risk of recurrence of infection due to implantation of hard ware, and risk of implant failure^[18]. Patients who chosen this technique were taken to the operative theater for Ilizarov external fixation removal and replaced by Interlocking intramedullary nail and autogenous bone graft at the docking site.

Follow-up was done till complete healing in both groups with minimum 2 years follow-up. We reviewed all cost involved in medical care in both groups, and the days of absence from work or school till full return to normal life. None of the cases involved had permanent disability.

In this study, all records were reviewed to calculate the cost of surgery, hospital stay and cost of treatment after discharge, and days of absence from work or school.

Cost was calculated in local currency (Egyptian pound), according to prices of years 2003-2006. Comparison between the two homogenous groups makes this study applicable anywhere all over the world.

Statistical analysis

Continuous variables are expressed as mean and Standard Deviation. Categorical variables are expressed as frequencies and percents. Student t test was used to assess the statistical significance of the difference between more two study group mean. Fisher's exact test was used to examine the relationship between Categorical variables.

Pearson's correlation

Pearson's correlation was used to assess the correlation between two continuous variables.

All statistical procedures were carried out using SPSS version 15 for Windows (SPSSInc, Chicago, IL, United States).

RESULTS

There was no statistically significant difference between the two groups of patients regarding age, sex, size of the bone defect as shown in Table 1. Regarding the total hospital cost the group treated by external fixation was less than the group treated by replacement of external fixation by internal fixation, the difference was statistically significant. On the other hand, Duration of external fixation, total absence from work or school, and total cost of medical care was less in the group of early removal of external fixation and replacement by internal fixation, and showed statistically significant difference (Table 1).

DISCUSSION

The cost of hospital stay and surgery in the group of external fixation only was 22.6 ± 3.3 , while the group of early external fixation removal and replacement by IM nail the cost of hospital stay and surgery was 26.0 ± 3.2 . The difference was statistically significant.

The total cost of medical care (surgery, hospital stay, treatment outside the hospital including medications, dressing, physical therapy, outpatient laboratory work, *etc.*) in group of external fixation only was 63.3 ± 15.1 , and total absence from work was 38.6 ± 6.6 wk. While the group of early removal of external fixation and replacement by IM nail total cost of medical care was 38.3 ± 6.4 and total absence from work or school was 22.7 ± 4.1 . The difference was statistically significant regarding the total cost and absence from work in favor of the group of early removal and replacement by IM nail.

Cost of medical care is an important issue all over the world. Health authorities and insurance systems keep asking the medical community about the cost effectiveness of different surgical procedures^[13]. The choice of method of treatment needs to give the best clinical outcome according to evidence based medicine^[15], to be cost effective, and able to achieve the best comfort for the patient and the earlier return to normal life with least burden on medical service^[16].

Planning to study cost effectiveness in different treatment modalities is difficult due to the difference in cost between different countries, and different places within the same country, and the change in cost over years, the type of currency used and inflation, *etc.* There are also the other medical and economic variables to be considered.

The cost of medical care can be different from a country to another. For example: Total hip replacement cost 47000 US Dollars in United States, 8500 US Dollars in Egypt or India, 12000 US Dollars in Singapore, and 10000 US Dollars in Malaysia, and 17 300 US Dollars in Mexico^[26,27]. Also the rise of medical cost over years can make comparison difficult^[28]. Even within the same country the cost of the same procedure can vary from a medical center to another^[29]. This variability can affect the interpretation of the results in this study and the applicability of the data in other countries. Comparing two homogenous groups of patients treated at the same center during the same period of time, by different techniques decrease this effect.

Every medical procedure carries some risks. Medical community needs to justify using this procedure or that. To do so, we as medical doctors and orthopaedic surgeons should do studies that review the clinical effectiveness and financial effectiveness of different surgical procedures.

In this study two techniques were reviewed. Both techniques give good final clinical outcome. Treatment of infected nonunion by external fixation as the only method of stabilization can be effective, and safe. But long duration of external fixation showed many medical problems and complications. Also the long duration of

Table 1 Comparison between two groups as regard all studied parameters

	Group				P	SIG
	External fixation with nailing		External fixation only			
	Mean	± SD	Mean	± SD		
Age	27.42	6.42	27.62	6.41	0.913 ¹	NS
Sex						
Male (n)	22	91.70%	25	96.2%	0.602 ²	NS
Female (n)	2	8.3%	1	3.8%		
Duration of external fixation	10.63	1.74	26.00	1.52	0.0001 ¹	HS
Duration to healing	24.54	0.83	26.00	1.52	0.0001 ¹	HS
Size of defect	4.13	0.74	4.04	0.77	0.688 ¹	NS
Hospital cost	26.00	3.18	22.65	3.35	0.001 ¹	HS
Total medical cost	38.30	6.40	63.35	15.08	0.0001 ¹	HS
Total absence from work/school	22.71	4.10	38.58	6.59	0.0001 ¹	HS

¹Student *t* test; ²Fisher exact test. Age in years; Duration of external fixation in weeks; Time to bone healing in weeks; Size of bone defect in centimeters; Hospital financial cost calculated in 1000 local currency; Total medical cost calculated in 1000 local currency; Total absence from work in weeks.

external fixation leads to delay in rehabilitation and longer absence from work or school, and showed a high total medical cost. This total cost is not only involving hospital cost, but involve the daily dressing, physical therapy, medications, and absence from work.

The other technique involves early removal of external fixation once infection is eradicated and segment transfer is finished, and replacement by intramedullary nail. This technique carries some risk for the recurrence of infection, and the higher cost of a second surgical procedure. But the total cost of medical care, and duration needed till return to work is less.

The treatment of infected nonunion has many techniques. Ilizarov is only one of these techniques. And within Ilizarov technique there are many modifications. This study was not able to review all techniques. But the design of this study, and the data available was used to compare two of these techniques, although in the future there should be studies to review every orthopaedic procedure and to show the clinical and cost effectiveness of this procedure.

There can be differences between different countries regarding details of medical care. In some countries the cost of medications or hospital stay or implant can be more than the other, on the other hand physical therapy in one country can cost less or more than the other. And there are many details within the medical care that can make difference in the cost. That is why in this study the comparison between the costs of two homogenous groups may compensate this defect and makes this study useful to medical society all over the world not only in poor countries or rich. The currency used to calculate the cost was the 1000 local currency. And this defect was also compensated by the comparison of two homogenous groups.

Orthopaedic community should focus on cost beside clinical effectiveness of different medical interventions to prove to the financial authorities the rationale behind the high cost of some orthopaedic procedures.

Some procedures can cost more money regarding hospital stay and surgery, but the total cost of medical care and absence from work can be less than another

procedure that has less surgical cost.

Early removal of external fixation and replacement by internal fixation after eradication of infection and finishing segment transfer is more cost effective and allow earlier return to work than the classic technique of segment transfer by Ilizarov external fixation only.

COMMENTS

Background

The cost of treatment and medical care is an important issue all over the world, not only in poor countries. This cost puts a huge burden on the financial, insurance and health authorities and also affect the productivity of the community. The cost in treatment of bone infection is not only the direct hospital cost of multiple surgeries but also the cost of care required at home including wound dressing, physical therapy, etc. There is the economic burden on the patient family, and community due to days of absence from work or school.

Research frontiers

The choice of method of treatment needs to give the best clinical outcome according to evidence based medicine, to be cost effective, and able to achieve the best comfort for the patient and the earlier return to normal life with least burden on medical service. Every medical procedure carries some risks. Medical community needs to justify using this procedure or that. To do so, medical doctors and orthopaedic surgeons should do studies that review the clinical effectiveness and financial effectiveness of different surgical procedures.

Innovations and breakthroughs

There are not so many papers in the scientific orthopaedic literature deal with the cost effectiveness of different surgical techniques. This study presents two techniques used in treatment of infected tibial nonunion. Both techniques involve segment transfer by Ilizarov external fixation. In one technique the external fixation is removed early after eradication of infection and finishing segment transfer, and replaced by intramedullary nail. The other technique is to continue with external fixation till full healing of the fracture, docking site, and distraction callus. The aim of our study is to compare the cost of the two different techniques including hospital and surgical cost, home care cost, and absence from work or school, and to define which would be more cost effective for the patient and the community.

Applications

Treatment of infected nonunion by external fixation as the only method of stabilization can be effective, and safe. But long duration of external fixation showed many medical problems and complications. Also the long duration of external fixation leads to delay in rehabilitation and longer absence from work or school, and showed a high total medical cost. This total cost is not only involving hospital cost, but involve the daily dressing, physical therapy, medications, and absence from work. The other technique involves early removal of external fixation once infection is eradicated and segment transfer is finished, and replacement by intramedullary nail. This technique carries some risk for the recurrence of infection, and the higher cost of a second surgical procedure. But

the total cost of medical care, and duration needed till return to work is less. Orthopaedic community should focus on cost beside clinical effectiveness of different medical interventions to prove to the financial authorities the rationale behind the high cost of some orthopaedic procedures. Some procedures can cost more money regarding hospital stay and surgery, but the total cost of medical care and absence from work can be less than another procedure that has less surgical cost. Future studies should be done to review every orthopaedic procedure and to show the clinical and cost effectiveness of this procedure.

Terminology

The cost of treatment and medical care include the cost of surgery, hospital stay, cost of treatment after discharge, and days of absence from work or school till full return to normal life. Segment transfer is a technique used to fill a bone defect, in which a bone corticotomy done in healthy bone and gradually transfer this bone segment to fill the bone defect.

Peer review

This is an interesting article that looks at the economics of two commonly performed surgeries for infected non unions.

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