



Original article

Postoperative infection in patients undergoing inspection of orthopedic damage due to external fixation[☆]



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ABSTRACT

Objective: To conduct a retrospective analysis on cases undergoing inspection of orthopedic damage, at an orthopedic emergency service in a teaching hospital, with the aim of evaluating patients with postoperative infection after conversion to internal osteosynthesis. **Methods:** This was a retrospective analysis covering the period from June 2012 to June 2013, on patients who underwent inspection of orthopedic damage due to external fixation and subsequently were converted to definitive osteosynthesis using a nail or plate.

Results: We found an infection rate of 13.3% in our sample and, furthermore, found that there had been technical errors in setting up the fixator in 60.4% of the cases.

Conclusion: We found an infection rate that we considered high, along with inadequacies in constructing the external fixator. We emphasize that this procedure is not risk-free and that training for physicians who perform this procedure should be mandatory.

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Infecção pós-operatória nos pacientes submetidos ao controle de danos ortopédicos pela fixação externa

RESUMO

Objetivo: Fazer uma análise retrospectiva de casos submetidos ao controle de danos ortopédicos em um pronto socorro de ortopedia de hospital-escola com o objetivo de avaliar os pacientes com infecção pós-operatória após serem convertidos para osteossíntese interna.

Métodos: Análise retrospectiva de pacientes de junho de 2012 a junho de 2013 submetidos ao controle de danos ortopédicos com fixador externo que posteriormente foram convertidos para osteossíntese definitiva, com haste ou placa.

Palavras-chave:

Infecção

Fixadores externos

Fixação interna de fraturas

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Resultados: Encontramos uma taxa de infecção de 13,3% em nossa casuística e verificamos erros técnicos na elaboração do fixador em 60,4% das oportunidades.

Conclusão: Foi encontrada uma taxa de infecção que consideramos alta, assim como de inadequações na confecção do fixador externo. Salientamos que esse procedimento não é isento de riscos e treinamento para médicos que o fazem deve ser obrigatório.

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Introduction

Damage control is the orthopedic surgical tactic established in the literature that is indicated for multiple trauma patients or those with severe soft-tissue injuries.¹ However, this procedure is not free from risks. Local and systemic complications associated with external fixation for damage control have been reported² and one of these is bone infection. Studies have shown infection rates along the paths of the pins ranging from 0.5 to 30%.^{2,3}

Bacterial contamination and infection along the path of the pins of external fixators are relatively common. Conversion to internal osteosynthesis under such conditions, which could involve use of intramedullary nails or plates, may give rise to severe local and/or systemic complications.⁴ The frequency of this association of events is unclear in the literature.³

The correlation between infection along the path of the pins of external fixators and post-traumatic osteomyelitis subsequent to internal osteosynthesis, thus configuring chronic infection of the locomotor system, is well established.^{5,6}

Infection of the bone–pin interface of the fixator has been proven to have a direct association with the insertion technique, with regard to the stability and positioning of the limb during pin placement, given that this might give rise to tension within the soft tissues. Presence of these factors contributes toward infectious complications subsequent to conversion to definitive internal osteosynthesis, irrespective of whether this will involve an intramedullary nail or a plate.^{7,8}

The aim of our study was to identify the quality of reduction and fixation and the frequency of bone infection after definitive treatment, among patients who were admitted to an emergency service over a one-year period and underwent musculoskeletal damage control.

Sample and methods

This study was duly submitted to and approved by our institution's ethics committee and was registered under the committee's protocol number 624.307.

Retrospective evaluations were made on 120 patients who underwent external fixation to control musculoskeletal damage between June 2012 and June 2013, attended as emergencies at the emergency service of our institution's Department of Orthopedics and Traumatology.

In this retrospective study, we included patients who underwent damage control surgery consisting of external

fixation and who, after conversion to definitive osteosynthesis, evolved with infection.

Patients who presented infectious complications in the presence of local and systemic alterations such as vasculopathy, diabetes mellitus or consumptive disease, and patients with psychiatric disorders that might have impaired the evolution of the condition or care provided for the fixator in some manner, were excluded.

All the radiographs were generated in digital form and were analyzed through the Impax software. The distances from the orifice and Schanz pins to the definitive synthesis were analyzed within this software. We sought to identify any presence of technical errors during the drilling (characterized by multiple drilling), with subjective analysis conducted by three different groups of two evaluators. One group was formed by attending physicians with at least five years of experience in orthopedic trauma; another group was formed by two third-year residents and a third group was formed by two residents in the second year of orthopedics. The evaluators were named as follows (Table 1):

- Evaluator 1: attending physician with more than five years of experience
- Evaluator 2: attending physician with more than five years of experience
- Evaluator 3: third-year resident
- Evaluator 4: third-year resident
- Evaluator 5: second-year resident
- Evaluator 6: second-year resident

Postoperative infection was characterized by means of a clinical examination conducted during hospitalization or at an outpatient investigation, from the data noted in the medical files. The clinical criteria for infection were taken to be the following: erythema, hyperemia or fistula along the paths of the pins or in the surgical incision (Fig. 1).

During the external fixation, the holes drilled previously using a bit were always respected and the pins were inserted manually. None of the pins were in the zone of exposure of the fracture.

In evaluating the radiographs, we observed the pre and postoperative examinations and measured the positions of the Schanz pins and their distances from the definitive synthesis. We took the presence of drilled holes in numbers greater than the number of pins installed to suggest that there had been some difficulty and additional damage in installing the external fixator. We also noted any presence of osteolysis in the orifices through which the Schanz pins were installed, and whether the drill hole locations for the pins brought any

Table 1 – Analysis on the cases by the group of evaluators.

Case	Attending physician 1	Attending physician 2	R2a	R2b	R3a	R3b
1	Inadequate	Adequate	Inadequate	Inadequate	Adequate	Inadequate
2	Inadequate	Adequate	Inadequate	Adequate	Adequate	Inadequate
3	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate
4	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate	Adequate
5	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate	Adequate
6	Adequate	Adequate	Inadequate	Inadequate	Adequate	Inadequate
7	Inadequate	Adequate	Adequate	Inadequate	Inadequate	Inadequate
8	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate
9	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate
10	Adequate	Inadequate	Inadequate	Inadequate	Adequate	Inadequate
11	Inadequate	Adequate	Inadequate	Inadequate	Inadequate	Inadequate
12	Inadequate	Adequate	Adequate	Adequate	Inadequate	Inadequate
13	Adequate	Adequate	Inadequate	Adequate	Adequate	Adequate
14	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate
15	Inadequate	Adequate	Inadequate	Inadequate	Adequate	Inadequate
16	Inadequate	Inadequate	Inadequate	Inadequate	Adequate	Inadequate

problems for the definitive internal fixation. Among these problems, we noted any cases of surgery postponed because of infection along the path of the pin, changes to the surgical incision for definitive osteosynthesis and unplanned surgical procedures for reassembling the fixator because of an unstable assembly.

The mean time taken for conversion of the external fixators to definitive osteosynthesis was evaluated through retrospective analysis on the medical files.

Results

Out of the 120 patients who underwent damage control, 16 (13.3%) suffered post-traumatic osteomyelitis after the definitive synthesis. Among these 16 patients, their condition could be directly correlated with the definitive internal osteosynthesis because there were no signs of local infection after the external fixation at the emergency service.

The mean age of these 16 patients was 43.4 years, with a range from 19 to 81. We noted that male patients predominated, comprising 13 patients (81.2%), and the remaining three (18.8%) were female.

Regarding the time taken for conversion of the external fixator to definitive osteosynthesis, the shortest period was five days and the longest was 30 days. The mean time taken for the definitive conversion was 15 days.

Infection occurred in eight cases of lower-leg fracture alone (50%), while two patients had fractures of the femur and ipsilateral tibia (floating knee) (12.5%), two had fractures of the

ankle (12.5%), two had fractures of the tibial plateau (12.5%), one had a fracture of the femur alone (6.2%) and one had a fracture of the humerus (6.2%).

Among these 16 patients with post-traumatic infection, 37.5% of the cases (six patients) occurred after closed fractures and 62.5% (10 patients) after exposed fractures of Gustilo grade 3A (Table 2).

In 10 patients (62.5%), the fixator was assembled across the joint, while it was monostotic with monolateral configuration in the other 6 patients (37.5%), with tube-to-tube connection.

Regarding the etiological agent, it was adequately identified in 10 (62.5%) of the 16 infected patients. In one-third of these, multiple bacteria were observed and surgery was required for cleaning, debridement and curettage of the path from the pin orifice. The polymicrobial findings from the intraoperative cultures were the following: *Staphylococcus aureus*, coagulase-negative *Staphylococcus*, *Klebsiella* sp, *Acinetobacter baumannii* and *Pseudomonas aeruginosa*.

Regarding the objective evaluations on multiple bone drilling, we observed that there were more drilled holes than holes used for pins in eight patients (50%) of the 16 patients presenting infection after the definitive osteosynthesis (Fig. 2).

From measuring the distance between the position of the Schanz pin and the osteosynthesis, we found a mean of 2.2 cm, with a range up to 6 cm. In seven cases (43.8%) among the 16 infected cases, the distance measured was 0 cm, two were between 1 and 2 cm, two were between 3 and 4 cm, one was between 4 and 5 cm, three were 5 cm and one was 6 cm (Table 2). Regarding the evaluation of the quality of the fixation and reduction, we observed that among the 16 cases, the six evaluators agreed in four cases (25%), of two cases were considered to have adequate fixation and the other two, inadequate; five evaluators agreed in five cases (31.3%) with regard to quality, among which two were considered adequate and three, inadequate; four evaluators agreed in four cases (25%) with regard to the evaluation, such that all these four cases were considered inadequate; and in three cases (18.7%) there was no agreement between the evaluators, such that three considered that the fixation and reduction were adequate and three considered that these were inadequate (Table 3).



Fig. 1 – Infection along the path of a Schanz pin.

Table 2 – Distribution of the patients studied.

Name	Sex	Age	Fracture location	Gustilo	External fixator	Pin number	Distance from pin to definitive synthesis	Presence of multiple drilled holes	Time taken until conversion
1	M	19	Lower leg	3A	Transarticular over ankle	4	6 cm		30 days
2	M	73	Lower leg	3A	Transarticular over knee	4	5 cm		14 days
3	M	43	Lower leg	3A	Linear on lower leg	4	3.2 cm (locking screw)	x	14 days
4	M	19	Lower leg	3A	Linear on lower leg	4	1.5 cm (locking screw)	x	6 days
5	M	36	Lower leg	3A	Linear on lower leg	4	4.3 cm (locking screw)	x	9 days
6	M	24	Femur	3A	Tube-to-tube on femur	4	1 cm	x	21 days
7	M	33	Humerus	3A	Transarticular over elbow	4	0	x	10 days
8	M	24	Femur + lower leg	3A	Transarticular over knee	8	0		5 days
9	M	56	Lower leg	3A	Linear on lower leg	6	0	x	21 days
10	M	37	Plateau	0	Transarticular over knee	4	0	x	13 days
11	M	31	Femur + knee	3A	Transarticular over knee	8	0	x	15 days
12	F	81	Ankle	0	Transarticular over ankle	4	0		15 days
13	F	71	Ankle	0	Transarticular over ankle	4	5 cm		6 days
14	M	25	Lower leg	0	Linear on lower leg	4	5 cm (locking screw)		10 days
15	F	74	Tibial diaphysis + fibula	0	Transarticular over ankle	4	3.5 cm		21 days
16	M	49	Plateau	0	Transarticular over knee	4	0		10 days

**Fig. 2 – Multiple drilling in a tube-to-tube fixator assembly.****Table 4 – Analysis on cases according to evaluator.**

Evaluator	Number of adequate cases (%)	Number of inadequate cases (%)
1	5 (31.3)	11 (68.7)
2	10 (62.5)	6 (37.5)
3	9 (56.2)	7 (43.8)
4	5 (31.3)	11 (68.7)
5	4 (25)	12 (75)
6	5 (31.3)	11 (68.7)
Total	38 (39.6)	58 (60.4)

In 13 cases (81.2%) in which there was some agreement (adequate or inadequate), the fixation was considered adequate in four cases (30.8%) and inadequate in nine cases (69.2%).

In analyzing the evaluations, we had a total of 96 evaluations. The fixation was considered adequate in 38 of these (39.6%) and inadequate in 58 (60.4%). In analyzing each evaluator's decisions, we found the following: for evaluator one, five cases (31.3%) evaluated as adequate and 11 (68.7%) as inadequate; for evaluator two, 10 cases (62.5%) as adequate and six (37.5%) as inadequate; for evaluator three, nine cases (56.2%) as adequate and seven (43.8%) as inadequate; for evaluator four, five cases (31.3%) as adequate and 11 (68.7%) as inadequate; evaluator five, four cases (25%) as adequate and 12 (75%) as inadequate; and evaluator six, five cases (31.3%) as adequate and 11 (68.7%) as inadequate (Table 4).

In evaluating the orthopedists with more than five years of experience alone, there were 32 evaluations, in which the fixation was considered adequate in 15 (46.9%) and inadequate

Table 3 – Evaluation of the cases.

Number of evaluators	Total number of cases (%)	Number of adequate cases	Number of inadequate cases
6 evaluators	4 (25)	2	2
5 evaluators	5 (31.3)	2	3
4 evaluators	4 (25)	0	5
3 evaluators	3 (18.7)	3	3

Table 5 – Evaluation according to experience.

Evaluator	Number of adequate cases (%)	Number of inadequate cases (%)
Attending physician	15 (46.9)	17 (53.1)
R3	14 (43.7)	18 (56.3)
R2	9 (28.1)	23 (71.9)
Total	38 (39.6)	58 (60.4)

in 17 (53.1%) (Table 4). In this group, there was agreement regarding the quality of the fixation and reduction in nine cases (56.3%) and disagreement in the other seven cases (43.7%). Among the nine cases with agreement, the quality of the reduction and fixation was considered adequate in four cases (44.4%) and inadequate in five (55.6%).

In evaluating the third-year residents alone, there were 32 evaluations, in which the fixation was considered adequate in 14 (43.7%) and inadequate in 18 (56.3%) (Table 4). In this group, there was agreement regarding the quality of the fixation and reduction in nine cases (56.3%) and disagreement in the other seven cases (43.7%). Among the nine cases with agreement, the quality of the reduction and fixation was considered adequate in four cases (44.4%) and inadequate in five (55.6%).

In evaluating the second-year residents alone, there were 32 evaluations, in which the fixation was considered adequate in nine (28.1%) and inadequate in 23 (71.9%) (Table 4). In this group, there was agreement regarding the quality of the fixation and reduction in 13 cases (81.3%) and disagreement in the other three cases (18.7%). Among the 13 cases with agreement, the quality of the reduction and fixation was considered adequate in three cases (23.1%) and inadequate in 10 (76.9%).

Among the evaluations in which the fixation was considered adequate, it could be seen that there was a tendency toward similarity of evaluations between the attending physicians and the third-year residents, but fewer cases were considered adequate among the second-year residents (Table 5).

In comparing the cases in which there was agreement in the evaluations between the attending physicians and the third-year residents, we observed that there was agreement in five (31.3%) of the 16 cases, among which the reduction and fixation was considered adequate in three and inadequate in two. Among the other 11 cases, although the attending physicians agreed in their evaluations in four cases, they did not agree with the third-year residents: of these, the reduction and fixation were considered adequate by the attending physicians in one case and inadequate in three cases.

In comparing the cases in which there was agreement in the evaluations between the attending physicians and the second-year residents, we observed that this was seen in seven (77.8%) of the nine cases. Of these, the reduction and fixation were considered adequate in two cases and inadequate in five cases. In one case in which the attending physicians agreed that the fixation was adequate, the second-year residents considered that it was inadequate.

In evaluating the seven cases in which there was no agreement between the attending physicians with more than five years of experience, we observed that in one case, the

residents (both third and second-year) also did not agree. In four cases, the two evaluators who were third-year residents also did not agree, while in three cases, the two evaluators who were third-year residents agreed, such that they both considered that the reduction and fixation were inadequate. Among the seven cases in which the attending physicians did not agree, the evaluators who were second-year residents considered that the reduction and fixation were adequate in one case and inadequate in four.

Discussion

External fixators, which are fixation devices of greater versatility that enable a variety of types of assembly and configuration, can be put in place quickly. They are applied percutaneously to treat fractures in emergency situations so as to control the damage with less damage to soft tissues.

This procedure, applied in both a provisional and a definitive manner, is still used routinely in many hospital services. It was found to be chosen by 32 to 89% of a group of orthopedists in a previous study.⁹ However, this procedure is not free from risks.

In our sample, we found that the frequency of infection after using an external fixator for damage control was 13.3%. Although this rate is compatible with those in the literature, which range from 0.5 to 30%,^{2,3} we are concerned about this because we judge that this rate is very high among the possible complications.

The first issue to be borne in mind in seeking the etiology of the infection is always the environment in which the treatment takes place, which in our case was a teaching hospital. There seems to be a weak correlation between cause and effect, given that this procedure is considered to be one of low complexity and there would be at least one physician with three years of training in the surgical team.

Another factor that is involved in complications from infection after internal osteosynthesis is infection of the path of the Schanz pins. Among our patients, presence of a clinical suspicion of infection was an indication for changing the pin installation to another location, or for continuing the treatment with osteosynthesis by means of an external fixator.

The reduction and fixation were considered to be inadequate in 60% of the evaluations. This proportion can be considered to be very high: on average, the attending physicians and third-year residents found that the reduction and fixation were adequate in only 50% of the evaluations. This shows that there is a need for better teaching with regard to treatments in emergency situations using external fixators.

External fixation is often neglected in our setting, in relation to both the preoperative scheduling and the procedure and subsequent care. In any procedure for external fixation, the future definitive synthesis should always be considered in assembling the fixator and placing the pins. This situation should always be discussed with the attending physician, in order to draw up a preoperative schedule with a view to future synthesis, using either a plate or a nail. In our study, in 43.8% of the cases, the location of the Schanz pin

did not have any distance from the definitive osteosynthesis.

The correct pin insertion technique and care with the dressing and operative wound are essential for preventing these complications.^{9,10} Pre-drilling, manual pin insertion and use of a safety corridor are factors that cannot be forgotten during the fixation. Systematization of this intra and postoperative care is a factor that can be controlled by the physician in order to influence the infection rate of the path of the Schanz pins, for damage control.

In routine practice, the quality of the fracture reduction is not so important in considering postoperative infection, given that the use of external fixation is temporary.⁸ However, in some situations in which the fixator remains in place for a prolonged period, this factor needs to be taken into account. In our sample, the longest time that elapsed until conversion was 30 days. Temporary reduction is important for stabilizing the condition, and for local care and the general condition.

In our cases, we observed that all of them presented a safety corridor that was seen to be respected in analyzing the radiographs (in our sample, no neurovascular lesions were observed).

In order to identify the importance of the quality of the installation and spatial assembly of the external fixators, we asked physicians with different lengths of training to judge the quality of the assembly and to determine rates of technical inadequacy from radiographs in the files. In our study, 60% of the cases were considered to be technically inadequate, which was a very high rate.

Regarding the frequency of bone infection after damage control, we found that among the 13% with infection, occurrences of errors or technical inadequacies may have contributed toward the undesirable outcome in 50%.

In considering the assemblies of the external fixators, we were unable to correlate the frequency of infection with any given type of assembly. Transarticular assemblies, which are used for meta-epiphyseal fractures, fractures of ipsilateral bones and extensive soft-tissue lesions, in order to avoid post-traumatic joint deformities, were the most prevalent type, in 62.5% of the cases.

Although it was not possible to correlate internal post-osteosynthesis infection with the use of fixators for damage control, the presence of inadequacy of the assemblies that were installed in the emergency service suggested that there is a need for training and for rules for fixator assembly and use.

Conclusion

Bone infection occurred in 13.3% of the cases treated with musculoskeletal damage control followed by internal osteosynthesis. In these cases, the reduction and fixation were considered adequate in 39.6% of the evaluations and inadequate in 60.4%. We emphasize that this procedure is not free from risk and that training for the physicians who perform it should be obligatory.

Conflicts of interest

The authors declare no conflicts of interest.

REFERENCES

1. Scalea TM, Boswell SA, Scott JD, Mitchell KA, Kramer ME, Pollak AN. External fixation as a bridge to intramedullary nailing for patients with multiple injuries and with femur fractures: damage control orthopedics. *J Trauma*. 2000;48(4):613-21.
2. Parameswaran AD, Roberts CS, Seligson D, Voor M. Pin tract infection with contemporary external fixation: how much of a problem? *J Orthop Trauma*. 2003;17(7):503-7.
3. Mahan J, Seligson D, Henry SL, Hynes P, Dobbins J. Factors in pin tract infections. *Orthopedics*. 1991;14(3):305-8.
4. Harwood PJ, Giannoudis PV, Probst C, Krettek C, Pape HC. The risk of local infective complications after damage control procedures for femoral shaft fracture. *J Orthop Trauma*. 2006;20(3):181-9.
5. Green SA, Ripley MJ. Chronic osteomyelitis in pin tracks. *J Bone Joint Surg Am*. 1984;66(7):1092-8.
6. Clasper JC, Cannon LB, Stapley SA, Taylor VM, Watkins PE. Fluid accumulation and the rapid spread of bacteria in the pathogenesis of external fixator pin track infection. *Injury*. 2001;32(5):377-81.
7. Moroni A, Vannini F, Mosca M, Giannini S. State of the art review: techniques to avoid pin loosening and infection in external fixation. *J Orthop Trauma*. 2002;16(3):189-95.
8. Cardozo RT, Silva LG, Bragante LA, Rocha MA. Tratamento das fraturas diafisárias da tíbia com fixador externo comparado com a haste intramedular bloqueada. *Rev Bras Ortop*. 2013;48(2):137-44.
9. Balbachevsky D, Belloti JC, Martins CVE, Fernandes HJA, Faloppa F, Reis FB. Como são tratadas as fraturas expostas da tíbia no Brasil? Estudo transversal. *Acta Ortop Bras*. 2005;13(5):229-32.
10. Petinne KA, Chao EY, Kelly PJ. Analysis of the external fixator pin-bone interface. *Clin Orthop Relat Res*. 1993;293:18-27.