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No role for antiseptics in routine pin site care in Ilizarov fixators: A randomised prospective single blinded control study☆

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ABSTRACT

Introduction: Pin site infection is the commonest complication of Ilizarov external fixation. The aim of the study was to examine if use of antiseptics was superior over control and further if daily dressing was superior to weekly dressing in regular pin site care in reducing the burden of pin site infection in Ilizarov fixators.

Patients and methods: A total of 114 patients (2363 pin sites) were randomised to receive regular pin site care alone (30 patients, 638 pin sites) or with additional application of povidone iodine (27 patients, 561 pin sites), silver sulfadiazine (27 patients, 570 pin sites) and chlorhexidine (30 patients, 594 pin sites). The pin tracts were sub-randomised to receive daily (1212 pin sites) or weekly (1151 pin sites) dressings. The primary outcome was pin site infection days rate across all four groups. The secondary outcomes were - mean duration to first episode of infection, differences between daily and weekly dressing groups, mean duration of antibiotic therapy and incidence of re-interventions and sequelae. We also recorded frequency of bacterial pathogens in all microbiological samples submitted. Block randomization using computer-generated random numbers was used. The assessor of outcome was blinded.

Results: All patients completed the study. Pin site infection rate days per 1000 pin site days observed was marginally less in chlorhexidine group, but was not statistically significant compared to other antiseptics and control group (Absolute value in control, povidone iodine, silver sulphadiazine and chlorhexidine groups were respectively 2.04 ± 4.27, 2.04 ± 3.65, 1.85 ± 3.37, 1.37 ± 2.35, p value 0.92). Daily dressing category showed slightly less pin site infection days rate within each group and overall, but this was also not statistically significant (1.56 ± 3.99 versus 2.10 ± 5.1, p value 0.35). There was no statistically significant difference among the groups with regard to other secondary outcomes. Methicillin Sensitive *Staphylococcus aureus* was the most common bacterial pathogen isolated.

Conclusion: Use of antiseptics does not offer any advantage in regular pin site care in Ilizarov external fixation and daily pin site care is not superior to weekly pin site care. Empirical therapy in early and low grade pin site infections must be targeted against Staphylococcus.

Introduction

Ilizarov external fixator is a unique and versatile device with wide-spread applications in the field of Orthopaedics and Trauma. With the addition of newer modifications of the original system, the indications of its use are being refined day by day. Pin site infection undoubtedly is the commonest complication associated with Ilizarov external fixation [1]. Depending on reference the incidence of pin site infection in external fixation is reported variably from 0 to 100% [2].

Though antiseptics are used by many surgeons to prevent pin site infections, clear-cut evidence to support their use remains uncertain [3]. Also the recommendation for the frequency of pin site care varies from four times a day to as much as once in a week [4]. Some studies have gone to the extent of recommending that pin sites can be just left untouched after application of external fixators [5]. In summary, there are no evidence-based recommendations for routine pin site care in external fixators, including Ilizarov devices [1].

Some randomised control trials on the effectiveness of antiseptics in routine pin site care have come up with results

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supporting their use [6–9]. A slightly more number of randomised studies have concluded that antiseptics offer no advantage [5,10–15]. Though majority of studies have used daily dressing protocol, there is no clear evidence supporting it [5–8,10,11,15]. The only available randomised study on frequency of dressings, keeping all other factors constant concluded that daily pin site care was not superior to weekly pin site care [16].

These studies differ widely in terms of antiseptics used, frequency of dressings, pin site care protocols, timing of observations and outcome measures. All systematic reviews and meta analyses acknowledged the poor quality of evidence available and failed to put forward ideal recommendations for pin site care in external fixators [2,17–19]. All of them suggest the need for future prospective trials with robust methods, sample sizes and follow-up.

We believed that use of antiseptics and daily dressings without any conclusive evidence supporting this practice could lead on to unnecessary burden on cost and human resources. We undertook the current study in this background to see if use of antiseptics was superior over control and further if daily dressing was superior to weekly dressing in regular pin site care of Ilizarov external fixation in reducing the burden of pin site infection.

Patients and methods

A prospective, randomised, single blinded superiority trial (parallel, 1:1:1:1 allocation) was undertaken to examine the role of antiseptics in routine pin site care. The study was approved by the Institutional Ethics Committee. It was a four arm trial, with one group acting as control and the other three allotted to routine use of three different antiseptics. Sample size was calculated using online software www.sealedenvelope.com as for superiority trial involving binary outcome [20]. Calculations were based on the prospective randomised study done by Lee et al [7]. With significance level (alpha) set as 5% and power (1- beta) as 95%, we derived that a minimum of 561 pin sites must be enrolled to each arm for statistical significance. We recruited more patients considering the risks of loss to follow-up and stopped recruiting once 561 pin sites in each group had complete longitudinal follow up till removal of Ilizarov fixator.

All patients who were offered Ilizarov external fixation in our Orthopaedic department at a tertiary level teaching hospital were considered. All surgeries were performed by the same fellowship-trained consultant, with standard wire and half pin insertion techniques. The inclusion criteria were patients of any age, both genders, Ilizarov applied for any indication other than bone infection, patients consented for regular weekly follow-up for inspection of pin sites. The exclusion criteria were patients with history of bone infection, active soft tissue infection in the segment of Ilizarov fixator application and unwillingness for regular weekly follow-up. The cases where conventional or monolateral external fixators (with only half pins) were not considered for the study.

Between January 2017 and December 2017, 142 patients had Ilizarov fixator applied for various indications. Eliminating 20 patients with history of osteomyelitis and eight patients who were not willing for weekly follow-up, we enrolled 114 patients to our study. Patients were randomized to four groups by an independent allocator using block randomization with randomly mixed block sizes of four, six, eight, etc. with concealed sizes of block. He made random cards in sealed envelopes using computer-generated random numbers. In case, individual code-breaking was needed, a duplicate set was kept ready. The patient could not be blinded, as the intervention was obvious. But the outcome assessor, who longitudinally followed-up all patients on a weekly basis was blinded to the allocation of intervention.

A total of 114 patients and 2361 pin sites were enrolled into the study. After randomisation, they were allocated into control group (30 patients, 638 pin sites), povidone iodine group (27 patients, 561 pin sites), silver sulfadiazine group (27 patients, 570 pin sites) and chlorhexidine group (30 patients, 594 pin sites).

Pin sites of all selected cases were labelled (with stickers) according to a systematic nomenclature system by the operating surgical team. Rings named R1, R2, R3 . . . from proximal to distal. Pin-skin interphases were labelled as Metaphyseal (M1, M2, M3 . . .), Diaphyseal (D1, D2, D3 . . .), Schanz screws (S1, S2, S3 . . .).These pin sites were further grouped into proximal set and distal set, each having half of pin sites and again randomized within each patient to receive daily or weekly dressing. Daily and weekly pin sites were identified with two different colours (Fig. 1). According to randomisation, the same team educated the patient about regular pin site care and supervised the same. The outcome assessor was kept out of this process.

The patients did the pin site care with sterile packs provided from the hospital. Pin sites were wiped with normal saline with sterile applicators and dried with sterile gauze. Except in patients who belonged to the control group, corresponding antiseptic ointment was applied at pin-skin interphases (10% povidone iodine, 1% silver sulphadiazine and 1% chlorhexidine). Pin sites were covered with dry gauze pieces and rubber stoppers were applied. Each patient had half of his pin sites dressed daily and another half weekly, based on colour-coded stickers.

Follow-up assessment was performed by a dedicated blinded observer. He assessed all pin sites once weekly for any evidence of infection. Any evidence of intervention (such as povidone iodine staining) was removed before the patient reported to the assessor. The assessor was not aware of the colour coding for daily and weekly dressings. Once infection was detected, appropriate treatment was started according to Dahl Wire and Pin Site Classification (Table 1) [21] and patients were followed up on a daily basis by the dedicated observer. The patients were brought back to the original follow-up protocol after complete resolution of infection. A Consolidated Standards of Reporting Trials (CONSORT) flow diagram showing the enrolment, allocation of treatment, and passage through the study is summarised in Fig. 2.

The blinded observer also collected and recorded the following data pertaining to each patient – age, gender, body weight, presence of comorbidities, indication for Ilizarov surgery, body segment to which fixator was applied, total number of pin sites (metaphyseal, diaphyseal and Schanz screws) and total duration of external fixation. He also kept note of all the microbiological culture and sensitivity reports, duration of antibiotic therapy in

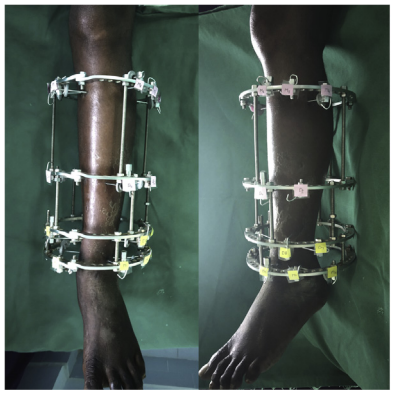

Fig. 1. Clinical photograph of Ilizarov external fixator with pin sites labelled systematically for longitudinal follow-up. Two different colours of the labels denote daily and weekly dressing subgroups.

Table 1
Dahl Wire and Pin Site Classification (1994).

Grade	Description	Action
0	Normal	Pin tract care as per randomisation
1	Inflammed	Daily inspection by the blinded observer. Twice daily dressing till resolution
2	Serous discharge	Daily inspection by the blinded observer. Twice daily dressing and empirical oral cefuroxime axetil till resolution. No microbiological examination.
3	Purulent discharge	Daily inspection by the blinded observer. Twice daily dressing. Sample sent for microbiological examination. Empirical oral cefuroxime axetil started and modified as per culture and antibiotic sensitivity report. Measures continue till resolution.
4	Osteolysis	Measures as Grade 3 plus removal or exchange of wire or half pin.
5	Ring sequestrum	Measures as Grade 4 plus debridement of pin site.

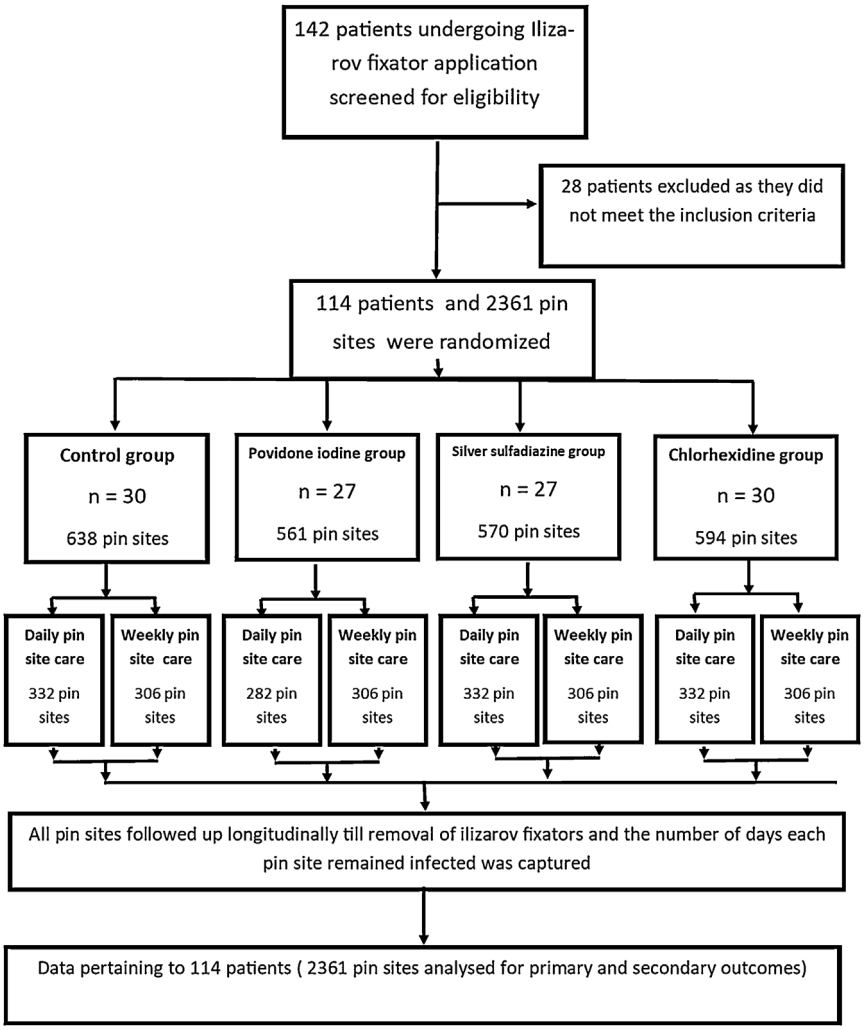

Fig. 2. Consolidated Standards of Reporting Trials (CONSORT) flow diagram showing the enrolment, allocation of treatment, and completion of the study.

each patient and recorded all interventions or complications in relation to pin site infections.

The primary outcome was called “pin site infection days rate”. The numerator was number of pin sites that got infected multiplied by number of days they remained infected. The denominator was number of pin sites observed multiplied by number of days for which they were observed. The sum of the numerators of every patient in each group was divided by the sum of denominators of every patient in each group. This was multiplied by 1000 to get a round figure. This value was compared across all four groups for statistically significant difference.

We decided that the following would be the secondary outcome measures - mean duration to first episode of pin site infection in all four groups, any difference in “pin site infection days rate” between daily and weekly dressing groups, mean duration of antibiotic therapy and incidence of re-interventions and permanent sequelae. We also intended to look for frequency distribution of bacterial pathogens in all the samples submitted for microbiological examination.

The study protocol had approval by the Institutional Ethics Committee. Written informed consent was obtained from all participants of the study. The manuscript was prepared according to CONSORT 2010 guidelines.

Statistical Analysis: The data collected analysed using IBM SPSS Statistics, Version 22 (Armonk, NY: IBM Corp). Continuous data with normal or skewed distribution were reported as mean (and SD) and median (and interquartile range (IQR)), respectively. Normality was assessed using a D'Agostino–Pearson test, Kruskal Wallis test was used to compare continuous variables with skewed distribution, while categorical data were reported as numbers (proportion). Pearson's chi square test and independent *t*-test were used to compare the categorical variables between the study groups. p value < 0.05 was considered statistically significant.

Results

All patients could be followed up till the removal of Ilizarov fixator. There were no protocol violations. The four groups were comparable with regard to baseline demographic and fixator characteristics (Table 2). The indications for which Ilizarov surgery was performed and the segments of the body on which external fixator was applied were also comparable across the four study groups (Table 3,4).

Ten patients had pin site infections in control and silver sulphadiazine groups, whereas 12 patients had pin site infections in the povidone iodine and chlorhexidine groups. The primary outcome – pin site infection rate days per 1000 pin site days observed – was marginally less in chlorhexidine group, but this difference was not statistically significant compared to other antiseptics and control group (Absolute value in control, povidone iodine, silver sulphadiazine and chlorhexidine groups were respectively 2.04 ± 4.27, 2.04 ± 3.65, 1.85 ± 3.37, 1.37 ± 2.35, p value 0.92). With secondary outcomes, though povidone iodine group showed slightly more delay in onset of infection, this effect was also not statistically significant (mean of 34.37 ± 52.6 days versus control 23.23 ± 40.0 days, p value 0.88). The effect was the same (lack of superiority of any antiseptic) both with daily and weekly dressings. (Table 5) The daily dressing category showed slightly less pin site infection days rate within each group and overall, but this effect was also not statistically significant (1.56 ± 3.99 versus 2.10 ± 5.1, p value 0.35) (Table 6). Duration of oral and intravenous antibiotic therapy was comparable in all four groups (Table 5). All the infections in the study group belonged to Dahl grades 1-4. None of our patients needed interventions for pin site infection or had chronic sequelae in relation to pin site infections.

Twenty nine patients had Grade 3 infection at some point of follow-up (according to Dahl Wire and Pin Site Classification) and

Table 2
Comparison of baseline demographic, clinical and external fixator characteristics among four treatment groups.

Variable	Total (n = 114)	Control group (n = 30)	Povidone iodine group (n = 27)	Silver sulphadiazine group (n = 27)	Chlorhexidine group (n = 30)	p value*
Mean age, years (SD)	32.7 (15.26)	32.6 (17.5)	34.2(16.2)	29.8(13.5)	34.1(12.8)	0.533
Male gender, n (%)	96(84.2)	26(86.7%)	22(81.5%)	23(85.2%)	25(83.3%)	0.951
Mean weight, kilograms (SD)	53.2(15.6)	52.1 (17.9)	54.6(15.2)	51(15.4)	55.1(13)	0.595
Diabetes, n (%)	4(3.5%)	2(6.7%)	1(3.7%)	0(0%)	1(3.3%)	0.6
Hypertension, n(%)	4(3.5%)	2(6.7%)	2(7.4%)	0(0%)	0(0%)	0.244
History of smoking, n(%)	12(10.5%)	3(10%)	4(14.8%)	3(11.1%)	2(6.7%)	0.794
Mean number of pin sites, per patient (SD)	20.7(7.02)	21.3(8.3)	20.8(6.7)	21.1(6.2)	19.8(6.7)	0.67
Mean number of pin sites in daily dressing category, per patient (SD)	10.6(3.7)	11(4.3)	10.4(3.3)	11(3.6)	10(3.6)	0.197
Mean number of pin sites in weekly dressing category, per patient (SD)	10.09 (3.55)	10.2(4.1)	10.3(3.7)	10.2(2.9)	9.7(3.6)	0.817

* By Pearson's chi square test (two-tailed).

Table 3
Comparison of indication for Ilizarov fixator application across four treatment groups.

Indication for Ilizarov fixator application	Total (114)	Control group (n = 30)	Povidone iodine group (n = 27)	Silver sulphadiazine group (n = 27)	Chlorhexidine group (n = 30)	p value*
Acute Open Fractures	16(14%)	3(10%)	3(11.1%)	3(11.1%)	7(23.3%)	0.4
Acute Closed Fractures	54 (47.4%)	14(46.7%)	11(40.7%)	12(44.4%)	17(56.7%)	0.656
Deformity of Foot and Ankle	16(14%)	4(13.3%)	5(18.5%)	4(14.8%)	3(10%)	0.83
Angular Deformity	5(4.4%)	3(10%)	1(3.7%)	1(3.7%)	0(0%)	0.297
Aseptic Non-union	12 (20.1%)	6(20%)	7(25.9%)	7(25.9%)	3(10%)	0.386

* By Pearson's chi square test (two-tailed).

Table 4
Comparison of the segment to which Ilizarov fixator was applied across four treatment groups.

Segment to which Ilizarov fixator was applied	Total (n = 114)	Control group (n = 30)	Povidone iodine group (n = 27)	Silver sulphadiazine group (n = 27)	Chlorhexidine group (n = 30)	p value*
Upper limb	10(8.8%)	2(6.7%)	2(7.4%)	2(7.4%)	4(13.3%)	0.784
Thigh	4(3.5%)	1(3.3%)	2(7.4%)	0(0%)	1(3.3%)	0.532
Leg	71(62.3%)	18(60%)	16(59.3%)	18(66.7%)	19(63.3%)	0.939
Ankle and foot	20(17.5%)	6(20%)	5(18.5%)	5(18.5%)	4(13.3%)	0.913
Thigh plus leg	9(7.9%)	3(10%)	2(7.4%)	2(7.4%)	2(6.7%)	0.967

* By Pearson's chi square test (two-tailed).

Table 5
Comparison of primary and secondary outcomes across four treatment groups.

Outcome	Control group (n = 30)	Povidone iodine group (n = 27)	Silver sulphadiazine group (n = 27)	Chlorhexidine group (n = 30)	p value*
Number of patients who had pin site infection, n(%)	10 (33.3%)	12 (44.4%)	10 (37.0%)	12 (40%)	0.86
Pin tract infection rate days, per 1000 pin tract days observed (SD)**	2.04(3.6)	2.04(4.3)	1.85(3.3)	1.37(2.3)	0.92
Mean duration to onset of pin site infection, days (SD)	23.2(40)	34.4(52.6)	34.4(51.8)	25.1(36.6)	0.88
Pin tract infection rate days in daily dressing category, per 1000 pin tract days observed (SD)	1.66(4)	1.87(4.8)	1.37(3.5)	1.34(3.8)	0.978
Pin tract infection rate days in weekly dressing category, per 1000 pin tract days observed (SD)	2.45(6.4)	2.28(6.3)	2.34(4.5)	1.37(3)	0.93
Mean duration of antibiotic therapy, days per patient (SD)	3.03(6.43)	1.55(3.5)	2.6(6.7)	0.9(2.37)	0.19
Mean duration of oral antibiotic therapy, days per patient (SD)	1.4(3.3)	1.5(2.9)	2.3(5.0)	0.9(2.37)	0.08
Mean duration of intravenous antibiotic therapy, days per patient (SD)	1.6(3.9)	0.25(1.3)	0.51(2.64)	0 (0)	0.11

* By Kruskal Wallis test.
** Primary outcome.

Table 6
Comparison of primary outcome between daily and weekly pin site care regimens, within each treatment group and overall.

Treatment group	Pin site care category	Pin site infection rate-days Mean (SD)*	p value**
Control group (n = 30)	**Daily**	1.66 (3.99)	0.49
	Weekly	2.45 (6.41)	
Povidone Iodine group (n = 27)	**Daily**	1.87 (4.82)	0.81
	Weekly	2.28 (6.31)	
Silver sulphadiazine group (n = 27)	**Daily**	1.37 (3.51)	0.26
	Weekly	2.34 (4.54)	
Chlorhexidine group (n = 30)	**Daily**	1.34 (3.76)	0.97
	Weekly	1.37 (3.01)	
Overall (n = 114)	**Daily**	1.56 (3.99)	0.35
	Weekly	2.10 (5.19)	

* Primary outcome.
** By independent *t*-test (two-tailed).

samples had to be sent for microbiological examination. One patient had two spells of Grade 3 infection and sample was sent twice. Thus there were 30 microbiological examinations. Out of these, three samples failed to grow any organism in culture (could be related to the empirical cefuroxime axetil therapy). Among the 27 samples that grew organisms, 21 samples grew only one organism, five samples grew two organisms and one sample grew three organisms. The various bacterial strains isolated against the number of patients from which they were isolated are summarised in Table 7.

Discussion

Despite evolution in the apparatus, surgical techniques and pin site care protocols, pin site infection continues to be the most common complication associated with Ilizarov external fixation. Data collected from the 1980s show a steady increase in the incidence of pin site infections associated with external fixators till the first decade of the 21st century with a slight decline in the last five years [2]. Due to wide variations in the definition of pin site infection, the existing literature on pin site infection is difficult to interpret [2].

Despite the availability of nearly 150 articles on pin site infections in existing literature [2], we could identify only 11 randomised control trials on the use of antiseptics in routine pin site care (Table 8). Four among them have supported the use of antiseptics [6–9] whereas the remaining seven studies report that antiseptics make no difference [5,10–15]. Only four [7,10–12] out of these 11 studies were done in patients on Ilizarov fixators where pin site infection is more relevant than in conventional external fixators and skeletal traction pin sites, considering the longer duration of external fixation. One among them supported the use of antiseptics [7], whereas the other three did not [10–12]. Again we believe that the studies on conventional external fixators and skeletal pin traction sites should not be extrapolated to Ilizarov fixators as the interphase between skin and tensioned wires behaves differently from that of Schanz screws.

There are many inconsistencies in the existing studies that make generalisation of studies difficult. Most of the studies are limited by small sample sizes (Table 8). Many studies differ in the frequency of dressing in the antiseptic and control groups which can act as a major confounder [6,13,14]. The increased frequency of dressing in control group could have biased the effect of the antiseptic which was administered in lesser frequency. Many studies have taken cross-sectional observations at one or more points of time after external fixator application, irrespective of whether the patients had episodes of infection before and after [7,9,11].

All available studies have compared the superiority of one antiseptic against a group of control patients. The different antiseptics used across various studies are chlorhexidine, hydrogen peroxide, povidone iodine, polyhexamethylene biguanide and silver sulphadiazine (Table 8). This wide variation in the use of antiseptics also makes comparison across studies difficult.

The choice of outcome measure also needs special mention. Some authors have reported the pin site infection rate as the number of patients who develop an infection over the course of treatment [10,13,15]. This does not indicate take into consideration how many pin sites got infected. Other authors have reported number of pin site infection occurrences divided by the total number of pins or wires [5–9,11,12]. Again this does not consider how long each pin site remained infected or whether one pin site

Table 7
Bacterial strains isolated from patients with Grade 3 pin site infections.

Bacterial strain isolated	No. of patients
Methicillin Sensitive Staphylococcus aureus	19
Coagulase Negative Staphylococcus	7
Klebsiella pneumoniae	4
Streptococcus pyogenes	2
Methicillin Resistant Staphylococcus aureus	2
Enterobacter spp.	1
Pseudomonas aeruginosa	1
Escherichia coli	1

got infected more than one time. Some authors have provided both outcome measures, still the limitations are not overcome [8,14].

We have attempted to overcome many of these limitations in our study. First of all, we recruited a large number of patients and pin sites into the study, powered enough for a four-arm study with three antiseptics and placebo, including subgroup analysis between daily and weekly dressing regimens. The choice of antiseptics was guided by the selection in the previous studies (Table 8) and local availability. We seem to have compared the maximum number of antiseptic within one study where comparison across studies is difficult. Another obvious merit of our study is that a dedicated and blinded observer followed up all pin sites from insertion till removal on a weekly basis. The patients were asked to report immediately at the earliest sign of infection and were followed up on a daily basis till infection was resolved. Thus we could accurately record how long each pin site remained infected. In comparison to existing literature, our choice of primary outcome measure comprehensively reveals the burden of infection as it takes into account the number of pin sites infected and the number of days for which they remained infected. Systematic randomization and complete follow up of all enrolled patients till fixator removal are other strengths of our study.

We acknowledge the following limitations of our study. First, the patients themselves did the pin site dressings after a comprehensive counselling and training session. There could have been variations and inconsistencies in their methods which could have influenced the results. There was no check or control over the volume of ointment applied at the pin sites. The method would have been stronger if health care providers (more specifically a single health care provider) did the dressings. But this was not practical considering the huge number of patients and pin sites and the need to dress half of the pin sites on a daily basis. We decided to keep the study method as close to the real life situation where patients are instructed to take care of the pin sites themselves. Secondly, the pin sites were examined at the time of fixator removal only for signs of infection. We did not document the condition of pin or wire – as firm, partially loose, completely loose – which comes as a consequence of pin site infection which definitely has an impact on the stability of the fixator. This was due to the practical difficulty in documenting the status of each wire or pin as they were being removed, chances of variations among observers or the need for a dedicated observer during every fixator

Table 8
Summary of Randomised Control Trials comparing the outcome of routine pin site care with or without antiseptics.

Study	Type of pin sites studied	Sample size	Frequency of pin site care	Treatment groups	Duration of follow-up	Conclusions with regard to reducing pin site infection burden.
Camathias et al. [5]	Conventional external fixator	56 patients, 204 pin sites	Daily	(1) Saline cleansing and povidone iodine dressing (2) no pin site care	Mean 55 days	No significant difference between two groups
Camilo et al. [10]	Ilizarov fixator	30 patients	Daily	(1) Saline cleansing followed by and povidone iodine (2) Saline cleansing and dry dressing	Mean 273 days (range, 95-726 days)	No significant difference between two groups
Cavusoglu et al. [11]	Ilizarov fixator	39 patients	Daily along with showering	(1) Cleaning crusts with sterile gauze with iodine solution (2) Brushing pin sites with soap and water.	At specific intervals till 150 days from fixator application.	No significant difference between two groups
Chan et al. [12]	Ilizarov fixator	60 patients, 788 pin sites	Daily	(1) Povidone iodine cleansing solution (2) Saline cleansing solution.	6 months	No significant difference between two groups
Egol et al. [13]	Conventional external fixator	118 patients	Daily / weekly	(1) Daily cleansing with half normal saline and hydrogen peroxide (2)Weekly change of chlorhexidine impregnated dressing (3) Dry gauze changed weekly	Mean 5.9 weeks	No significant difference between the groups
Grant et al. [6]	Skeletal traction pin sites	18 patients, 116 pin sites	Daily / twice daily	(1) Daily saline cleansing and paraffin ointment (2) Twice daily saline cleansing and dressing with povidone iodine	Mean 2 weeks (range 4-120 days)	Povidone iodine found superior
Lee et al. [7]	Ilizarov fixator	38 patients	Daily	(1) Polyhexamethylene biguanide impregnated gauze (2) Plain gauze	2, 4, 8 and 12 weeks after surgery	Polyhexamethylene biguanide dressing found superior
Ogbemudia et al. [14]	Conventional external fixator	98 patients, 636 pin sites	Daily / weekly	(1) daily dressing with sterile gauze and (2) weekly dressing with silver sulfadiazine cream.	Mean follow up was after 16 weeks from Ilizarov removal	No significant difference between two groups
Patterson et al. [8]	All types of external fixator	101 patients	Twice daily	Seven groups. Cleansing with half strength hydrogen peroxide, normal saline and soap and water with and without xeroform dressings versus control group where no specific intervention was done.	Data collected retrospectively at 6 week follow up visit	Use of hydrogen peroxide and xeroform dressings found superior.
W-Dahl et al. [9]	Conventional external fixator	50 patients	Weekly	(1) Chlorhexidine cleansing solution and impregnated gauze dressing (2) Normal saline cleansing and dry dressing	At 1,6 and 10 weeks postoperatively	Chlorhexidine found superior
Yuenyongviwat et al. [15]	Conventional external fixator	30 patients	Daily	(1) Cleansing with normal saline and dressing with silver sulfadiazine (2) Dry dressing	Mean of 106.3 and 108.6 days respectively	No significant difference between two groups

removal. Finally, our follow-up ended with the removal of Ilizarov fixator. Long term complications associated with pin sites like late presentation of infection or relapse of infection could have definitely enriched the study.

Conclusions

The use of antiseptics like povidone iodine, silver sulphadiazine or chlorhexidine does not offer any advantage in regular pin site care in Ilizarov external fixation and daily pin site care is not superior to weekly pin site care. Considering the frequency of association with pin site infections, empirical treatment for early and low grade pin site infections must be targeted against Staphylococcus.

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