Initially developed in the early 1990s, for the management of large, chronic, infected wounds that could not be closed in extremely debilitated patients, the use of vacuum-assisted closure (VAC) has been more recently used in the treatment of traumatic wounds [7]. VAC has dramatically changed the treatment of soft tissue injuries even in these orthopaedic trauma and infected wound patients. Recent studies have documented that VAC is a safe method for trauma wound even in cases with exposed bones [3,4,6,8,9]. It prevents deep infections as compared to simple dressings [10]. The aim of this study is to ascertain the efficacy of vacuum-assisted closure (VAC) dressing of contaminated soft tissue injuries in case of high energy trauma and infected wounds.

MATERIALS AND METHODS
Patients with high energy trauma including compound fractures in whom primary closure cannot be done and those with post-surgical wound dehiscence due to infections admitted to Jhalawar Medical College, Jhalawar, Rajasthan in the Department of Orthopaedics from July 2018 to June 2019 were taken for the study after taking the required consent.

Inclusion Criteria:
Patients giving informed consent to take part in study, one or more high-energy open soft tissue injuries, injuries judged survivable at patient presentation, received definitive wound management before discharge and available for follow-up for minimum one month after discharge.

Exclusion Criteria:
Patients with vital structures exposed (vessels/nerves), surgical contraindications because of medical, anaesthetic or surgical cause and patients having vascular injury in affected limb.

The management of patient began at the presentation in emergency department, the management of these high-energy open fractures require both skeletal stability and adequate soft tissue coverage. Bone stability on one hand can be achieved by external fixation or internal fixation but management of soft tissue injury is quite cumbersome and tiring for surgeon.

With the increase in the motor vehicular accidents the cases presenting with severe soft tissue trauma along with fractures are increasing in the emergency department, the management of these high-energy open fractures require both skeletal stability and adequate soft tissue coverage. Bone stability on one hand can be achieved by external fixation or internal fixation but management of soft tissue injury is quite cumbersome and tiring for surgeon.

In such injuries, the old school principle of repeated debridement of these wounds is to be followed but debridement of all nonviable tissue can produce significant soft tissue defects precluding healing through primary closures, delayed primary closures, or secondary intention [2].

Various treatment option like dressing with hydrocolloids, dressing with povidone iodine ointment or even synthetic skin graft for large soft tissue defects have been considered in literature and have been reported to be beneficial to the plastic surgeons managing acute wounds and burn injuries. However, in orthopaedic trauma, these methods have not been proven to be preventive of infection when bone is exposed [3-6].

The treatment of open wounds is variable and costly, demanding lengthy hospital stays or specialized home care requiring skilled nursing and costly supplies. Rapid healing of open wounds could result in decreased hospitalization and an earlier return of function. A method that improves the healing process could greatly decrease the risk of infection, amputation, and length of hospital stay and result in an estimated potential annual savings of billions of rupees of healthcare cost [1].

Initially developed in the early 1990s, for the management of large,
Criteria and written consent were taken. Included patients were started with VAC therapy.

**Material used for VAC:**
1. Foam which were autoclaved before application. 2. Adhesive Oclusive Dressing (we used IOBAN for coverage and sealing of wounds). 3. Connecting tube used for connecting the sealed dressing to the suction machine is from the easily available vacuum suction soft tissue (haemovac) drain. It provides two tubes that can be used in two settings. 4. Suction Machine (we used the available continuous suction line). (Figure 1)

**Technique:**
Initially the wound was thoroughly debrided and all the necrotic tissue removed, the raw surface washed with normal saline and chlorhexidine vaseline gauge applied, above this first layer of autoclaved sponge applied followed by second layer, in between the two layers of sponge the sterile drain tube is sandwiched, the entire dressing is then covered by antisepsic occlusive film dressing “IOBAN” in such a manner that the film covers the entire dressing with a margin of 5 cm. Then the tubing from the dressing is connected to suction machine and the intermittent suction is started kept at a pressure of around -125 mm of hg. The dressing is changed every 48 hours and in case of blockage if the pressure is not been maintained for time duration of around 30 minutes the dressing is changed stat.

**Simultaneous Management:**
Consists of antibiotic therapy as per the culture report, fracture stabilization continued. We graded the wound into:
- A. Abundant granulation tissue and ready for closure.
- B. Granulation tissue present but inadequate for closure, wound is clinically clean appearing.
- C. No granulation tissue, no gross purulence.
- D. Gross purulence/infected tissue

Any wound having grade B/C/D undergoes debridement as required and reaply the VAC dressing. When wound achieve Grade A, decision for wound coverage made. Wound with approximating margins closed primarily. While wound with exposed structures undergo a flap for coverage, otherwise a split skin graft (SSG) is done.

**Follow up:**
The patients were followed up clinically at regular intervals, for a minimum period of 1 month post final closure. (Figure 2)

**RESULTS**
A total of 25 patients was included in this study after fulfilment of inclusion criteria. 72% of patients belonged to 21–60 years age group, 6 patients (24%) were below 20 year and only 1 patient (4%) was above 60 year. Most of the patients included in study were males (80%).

Detailed history of patient was taken about mechanism of injury. In most of the cases the mechanism of injury was R.T.A i.e., road traffic accident (76%). Apart from RTA there were few patients with infection due to massage after injury, fall, machine injury, blast. All injuries involved were of high energy.

Superficial and deep infection were noted, no evidence of infection was noted in 22 (88%) patients. Deep infection with exposed bone occurred in only 1(4%) patient and superficial infection in 2(8%) after 3 vac applications. (Figure 3)

Mean duration of hospital stay of the patients was 18.36 days (Table 1). Time from date of admission to date of wound coverage was noted. Mean duration was 13.84 days (Table 2). Total number of surgical procedures required for coverage for 19(76%) patients were 2, 3 procedures were required in 5(20%) patients and only 1 (4%) patient required 4 procedures for coverage. Complications like skin maceration were noted in 2 (8%) patients.

### Table 1: Duration Of Hospital Stay

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<td>20%</td>
</tr>
<tr>
<td>Total</td>
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### Table 2: Time For Wound Definitive Closure

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<td>&gt;25</td>
<td>4%</td>
</tr>
<tr>
<td>Total</td>
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</table>

**DISCUSSION**
Severe open bony injuries remain a challenge for orthopaedic surgeon, frequently leading to complications, morbidity, and even amputations. Severe open fractures lead to a reported 25%–66% incidence of infection in the literature [11-13].

Vacuum assisted closure (VAC) is a relatively new treatment that has proven beneficial in various types of complex wounds [14-20]. Despite the loads of literature demonstrating the good results of VAC, there are two issues that still remain unaddressed. First there are very few randomized studies comparing VAC to conventional gauze dressing and secondly, out of these two, only one study has compared the use of VAC or NPWT to conventional gauze dressing by Stannard et al [21]. Other than that, most of the articles in the literature are either case reports or small case series and many do not involve complex traumatic wounds.

Recently the question about the cost of VAC therapy [22] has been raised with conventional devices, and success of Gauze based negative pressure therapy has been reported. So, this study was planned to evaluate the indigenous vacuum assisted wound closure therapy against the conventional saline gauze dressing.

In most of the cases the mechanism of injury was a road traffic accident i.e., 76% (19/25). Apart from these there were few patients with injury due other causes like fall, machine injury etc. All injuries presenting to us were of high energy. This is comparable to study by Stannard et al [21] in which, ~60% of patients were caused by road traffic accidents and also all injuries were high energy type.

In our study, mean time to wound coverage was 13.84 days while in a study conducted by Armstrong et al [23], their mean time to coverage...
was 56 days in vac group. This is probably attributed to the fact that we considered the duration from admission to date of final coverage procedure been done. We did not take into account the time to complete healing, as judgment of the healing is subjective and may not coincide with the follow up of the patient, hence may be a source of bias. All wounds in our study were traumatic in contrast to Armstrong et al [23] study which used chronic wound. Our results are supported by other studies Mous et al [24] which show mean time to ready for surgical closure to be 6 days in vac group.

Another outcome considered in our study was total hospitalization duration. Mean duration of hospital stay was 18.36 days. Study done by Stannard et al [21] revealed 9.5 days in vac group but authors didn’t mention about the results being significant. The outcome, the number of procedures to wound closure was not reported by any other studies. We found mean number of operative procedures are 2.28. Rate of infection was found to be 12 %. This is in accordance with Stannard et al [21] who had reported 5.4% infection rate in vac group.

CONCLUSION
In this prospective clinical study, we demonstrate that the use of Vacuum Assisted Closure (VAC) in patients presenting with soft tissue injuries with or without fracture due to high energy trauma and conclude that VAC improves wound healing and reduces duration of hospitalization, reduces infection in post-traumatic contaminated wound with or without fracture and smaller number of dressings required till coverage of the wound. So, acknowledging the fact that VAC has a definite role in traumatic wounds and it can be delivered effectively through indigenous VAC system, we recommend its regular use in all patients presenting with post traumatic soft tissue injuries and infected wounds, when primary coverage is not possible.

REFERENCES