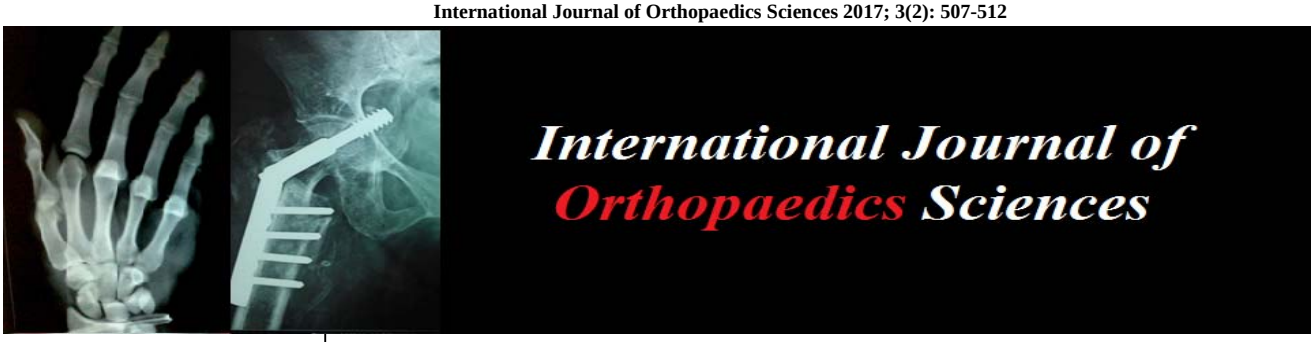

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Retrospective study of open tibial diaphyseal fractures type IIIA and IIIB by Ilizarov method

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Abstract
Background and objective: Open tibial fracture with or without bone loss in gustilo Anderson type IIIA and IIIB has been a challenge for most orthopaedic surgeons. Open tibial fracture is more prone for infection, non union and longer morbidity.
In this study, we have evaluated the results of 34 patients with open tibial fracture GA type IIIA and IIIB by Ilizarov method in retrospective manner. An attempt has been made to review the literature for the results of Ilizarov external fixator for open diaphyseal fracture and compare our results with standard studies.
Methods: In this retrospective study, 34 patients who are fulfilling our inclusion and exclusion criteria from Mumbai port trust hospital during the period of Dec 2012 to April 2016, treated for open tibial fracture by Ilizarov external fixator. Bone and functional results were evaluated using Tucker's criteria and Johners and wruh's criteria.
Results: Results were assessed using Tucker score and Johner and wruh's criteria and 91.1% had excellent to good result and 8.9% had fair to poor results using Tucker's criterion and 30 (88.23%) cases had excellent to good results and 4 (11.77%) cases had poor results using Johner and Wruh's criterion.
Conclusion: Ilizarov method is one of the method to treat open tibial fractures, advantages being the early weight bearing and treating infection, bone loss, fracture union and wound problem at the same time.

Keywords: Ilizarov fixator, open tibial fracture, Tucker's criteria, Johner and Wruh's criteria

Introduction
In this era of road traffic accidents, fracture of long bones are extremely common and fracture of tibia is commoner as it is subcutaneous. Their treatment, prognosis and outcome is determined by the mechanism of injury, degree of resulting comminution, soft tissue injury and displacement. The risk of delayed union and non union is increased with the degree of comminution. Open fractures are more prone to infection than closed fractures. More soft tissue injury increases the susceptibility to infection. In the long run, these fractures may go into non-union.
The options offered for the treatment of fractures of tibia range from Charnley's close reduction to the AO principles of the internal fixation and Gavril ilizarov external ring fixator.
Ilizarov has revolutionized the management of open tibial fractures which are more susceptible to the infection by allowing more union rates and early mobilization of the extremity and numerous other advantages which include wound management, limb lengthening and deformity correction among others. The tensioned wire circular external fixator has proved valuable in acute and subacute treatment of tibial fractures.

- There are many indication of Ilizarov method of external fixation but commoner are: [1]

1) Compound fracture
2) Comminuted fracture
3) Degloving injuries
4) Deformity correction
5) Infected non-union

Advantages of ilizarov method are
1. minimal violation of the soft tissue
2. Olive wires help to reduce fracture
3. Early joint mobilization
4. Early weight bearing
5. Immediate stabilisation
6. Bone loss management
7. Better wound care

In the developed countries, primary debridement and intramedullary nailing is now increasingly becoming the preferred treatment of these fractures. In our hospital, as in most centres in the less developed regions, open tibial fractures have been traditionally managed by external fixators. The high rate of failure associated with this management protocol made us to look to the Ilizarov external fixator (IEF) as an alternative. IEF is a step forward in the management of open tibial fractures in the settings where patients have bone loss, and facilities for emergency nailing are not available [2].

The complications in open injuries during the course of fracture treatment dictate the use of methods believed to reduce the risk of complications, including urgent or emergent treatment and thorough debridement of wound, consisting of removal of all foreign materials, removal of devascularised tissues and reduction of the bacterial load introduced by disruption of the soft tissue envelope. Hence, Ilizarov external fixator was studied for open tibial fracture Gustilo Anderson type IIIA and IIIB [3].

In this study we have carried out the Retrospective analysis of management of open tibial fracture with Ilizarov external fixator.

Aims and objectives

The main aim of this study is to:
1. Study the principles and method of Ilizarov External fixator in the treatment of open tibial shaft fracture grade IIIA and IIIB.
2. Evaluate the results obtained by treatment of open tibial shaft fracture grade IIIA and IIIB by Ilizarov external fixator.
3. Study treatment associated complications.
4. In this study, an attempt has been made to review the literature and compare our results with standard studies.

Materials and methods

Institutional review board and ethical committee permission was obtained for the study. All the patient in the Study were selected among those following up in Department of Orthopaedics, Mumbai Port Trust Hospital, Wadala, Mumbai. It is a retrospective study with a total 34 patients meeting the inclusive criteria were treated and were followed up from admission to post-operative period and rehabilitation and beyond. A minimum follow up duration of 12 months, initially once weekly for the first month, twice weekly for the next two months and monthly visits from the remainder of the duration. Study was conducted from May 2014 to April 2016. Maximum follow up in our study 30 months and Minimum follow up is 12 months. All the patient were following up in OPD from the period between Dec 2012 till April 2016.

Inclusion criteria
- Patient with type IIIA and IIIB compound tibial fracture (Modified Gustilo Anderson classification)[3]
- presenting within 72 hours of injury
- Patient willing for complete clinical and radiological follow up.
- Patients with minimum 12 months follow up

Exclusion criteria
- Polytrauma patients,
- types I,II and IIIC fractures,
- fractures with metaphyseal and articular involvement, and
- patients with associated fractures or injuries which precluded early mobilization

Thorough history of all the patients noted in the emergency room, such as mode of injury, time of injury, how patient is mobilized after injury etc.

Pre-operative assessment

Vital parameters were measured and noted. Radiographs were taken and detailed anatomy of fractures along with Modified Gustilo Anderson [3] classification were noted. Initial resuscitation, splintage and primary care for the wound was provided in the emergency room and swabs shall be taken for culture. Routine blood investigation, chest radiograph were done for anaesthetic fitness. Any protruding bone fragments shall be covered with sterile dressing and obvious foreign material shall be removed. The wound copiously washed with normal saline (about 6 litres for types IIIA and about 10 litres for type IIIB), and thorough debridement of all devitalised bone and soft tissue was done under anaesthesia. Only stay sutures was applied with a view to cover the bone, if possible. Consent for primary ilizarov fixation or temporary fixation was taken.

Surgical management

Anaesthesia: spinal or epidural anaesthesia was given in all our patients**.** To stabilise the fracture, we have applied definitive ilizarov fixator in most cases but sometimes an external fixator in the form of monoplanar, biplanar or hybrid fixator was applied to few patients in case of non availability of some Ilizarov fixator. Definite fixation with the IEF was carried out after three to five days of the initial emergency debridement in cases where external fixator was initially used. To save surgical time, pre-assembled frames were used. Four Ilizarov rings were used in most cases, although five or six rings were used if required. Corticotomy was added as and when required. Operative timing, tourniquette used or not, ilizarov technique were also recorded.

Post operative period

Ilizarov surgery is really a temporal extension of the surgical procedure and therefore needs the same high level of care and monitoring, that we apply during surgery. The postoperative period may be arbitrarily divided into three periods and during these three periods one lays emphasis on different aspects of care.

I. The early postoperative period (the latent phase)

Extends from the time the patient comes out of surgery until beginning of distraction. Pin sites and corticotomy sites are apparent to bleed and this was prevented by external tamponade. All bolts were tightened. Wires bent smoothly, schanz pins are cut as short as possible and cut ends covered with tape. Finally, Range of movements of the joints proximal and distal to the joint was checked. Early postoperative period – Analgesia through epidural catheter, followed by opioids

like tramadol and NSAID were used. Leg was positioned over a pillow so that knee should be fully extended at all the times. Passive dorsiflexion splints for ankle, all through the day and especially at night.

II. The distraction phase

Follow up checklist during this phase were distance moved on the threaded rods compared to previous visit, range of motion of adjacent joint and checking the neurological status The usual sequence of events in neurological injury during distraction is hyperesthesia in nerve distribution, hypoesthesia, anesthesia, motor weakness, complete palsy. If treated early and treated appropriately, function is completely regained. Pin sites were cleaned using 'Kurgan protocol.[4] Every patient was taught to bear weight and ambulation as soon as pain was relieved with proper sequence of heel strike and toe off. Rhythm and more so rate of distraction are not fixed numbers. Initially to start with when pain was more, we distracted the limb at 0.25 mm x 3 times of day, for 2-3 days followed 0.25 mm early 6th hourly. USG of regenerate was done to study for quality. The quality of the regenerate in transported cases was assessed by Fernandez-Estev grading, the frame being removed only after appearance of grade V regenerate in the radiographs. Radiological bony union is defined as when there is an evidence of structural callus as per Fernandez estev grading. When union appeared to be present (grade V regenerate in transported patients) the frame was dynamised for a three- to four-week period, followed by frame removal. Union time is defined as the time when both clinical (absence of pain or movement with the patient bearing full weight on the limb; the fixator attached but dynamised) and radiological union (presence of structural callus in two planes) were complete and all types of support or immobilisation was removed.

III. Consolidation Phase

At the end of distraction, Ilizarov recommended, "Training the regenerate". Simply put this involves overlengthening the limb by 7 to 10mm and then compressing back to proper length in gradual fashion. The fixator was neutralized so that weight-bearing stresses were transferred to newly formed osseous tissue achieved by reversing the ring 0.25mm alternate day, until rings no longer move towards each other. At this point, a monthly follow-up was sufficient. Movement and ambulation were encouraged for speedy consolidation of regenerate.

Removal of fixator

When patient is able to walk without pain and x rays reveal good new bone formation. Finally before actually removing the frame the patient were administered "stress test" in which all the upright connecting bolts, (Connecting proximal and distal fragments) were disconnected and the patient asked to use the limb in functional manner. If the patient is able to do this then frame is removed.

Post fixator removal

We used protective casts for 1 month. Strenuous activities and sports are avoided till such time as all four cortices are seen clearly.

After docking and radiographic union, skin closure was done by either split skin grafting or muscle or fasciocutaneous flaps or secondary intent healing.

Results

Table 1: Profile of Age in Our Study

AGE		
N	Valid	34
	Missing	0
Mean		37.74
Median		38.50
Std. Deviation		9.649
Minimum		19
Maximum		54

In our study, minimum age of the patient was 19 and maximum was 54 with a mean age of 37.74.

Table 2: Profile of Sex in Our Study

SEX		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	24	70.6	70.6	70.6
	Female	10	29.4	29.4	100.0
	Total	34	100.0	100.0	

Compound tibialfracture are more commonly present in males.

Table 3: Profile of Side in Our Study

Side	Number	Percentage
R	17	50
L	17	50

Both the side were equally involved.

Table 4: Profile of Occupation in Our Study

Occupation	Number	Percentage
Student	5	14.71
Housewife	5	14.71
Labourer	15	44.12
Scavanger	2	5.88
Clerk	1	2.94
Watchman	1	2.94
Shed officer	1	2.94
Attendant	1	2.94
Liftman	1	2.94
Messenger	1	2.94
Accountant	1	2.94

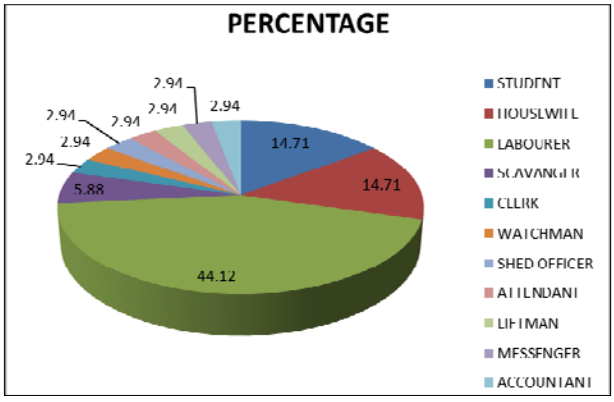

Chart 1: Pie chart showing occupation of the patient

Labourers have most commonly sustained open tibial fractures.

Table 5: Profile of Mode of Injury

Mode Of Injury	Number	Percentage
Rta (2 Wheeler)	16	47.06
Rta (4 Wheeler)	2	5.88
Fall Of Heavy Object	12	35.29
Rta (Pedestrian)	4	11.76

Compound tibial fractures are commonly seen in rta (2 wheelers).

Table 6: Profile of Level of Fracture

Level Of Fracture	Number	Percentage
PR	10	29.41
DI	13	38.24
MI	11	32.35

Distal tibial fractures were commonly seen followed by middle and proximal in order.

Table 7: Profile of Type of Fracture

Type Of Fracture	Number	Percentage
Spiral	1	2.94
Transverse	9	26.47
Oblique	5	14.71
Comminuted	12	35.29
Segmental	7	20.59

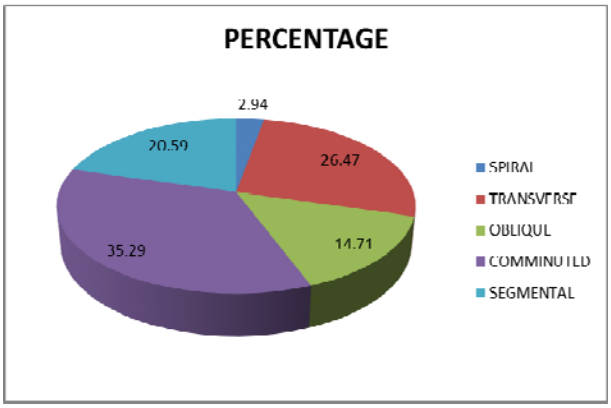

Chart 6: Pie chart showing type of fracture

Communited fracture were commoner than other types.

Table 8: profile of gustilo anderson type of fracture

GA Class	Number	Percentage
A	15	44.12
B	19	55.88

Type IIIB is more common fracture than type IIIA in our study.

Table 9: Profile of Bone Loss

Bone Loss In CMS	Number	Percentage
NIL	22	64.71
2	6	17.65
4	3	8.82
6	1	2.94
5	1	2.94
1	1	2.94

In our study, bone loss was present upto 6 cms.

Table 10: Profile of Initial Surgery

Initial surgery	Number	Percentage
IF	26	76.47
BPF	2	5.88
HF	3	8.82
MPF	3	8.82

IF- Ilizarov Fixator **HF-** Hybrid Fixator
BPF- Biplanar Fixator **MPF-** Monoplanar Fixator

Most of the time, Early Ilizarov fixator was applied as primary fixator except in certain situation like non-availability of ilizarov fixator we had used other methods like HF, MPF, BPF.

Table 11: profile of operation details

Operation details	Number	Percentage
Acute docking	22	64.71
Corticotomy	10	29.41
Acute docking with shortening	2	5.88
Bone graft	18	52.94
4 rings	27	79.41
6 rings	7	20.59

Acute docking was done in 64.7% and Acute docking with shortening done in 5.9%.Bone graft was done in 52.9% and corticotomy was done in 29.4% and Ilizarov with 4 ring in 79.4% and 6 ring in 20.6%.

Table 12: profile of method used for wound closure

Wound closure	Number	Percentage
SSG	25	73.53
LRF	5	14.71
SH	2	5.88
PC	2	5.88

Most commonly, split skin grafting was used for wound closure followed by local rotation flap and secondary healing and primary closure

Table 13: profile of second procedure done

2nd procedure	Number	Percentage
Nil	18	52.94
Wire tensioning	4	11.76
2nd debridement	6	17.65
Recorticotomy	2	5.88
Bone graft	1	2.94
Realignment	3	8.82

Secondary Debridement was done in 6 cases as a most common secondary procedure. Other things which were done were Wire tensioning (N=4), Realignment (N=3), Secondary bone graft(N=1) and Recorticotomy(N=2).

Table 14: profile of weight bearing started in post operative period

Weight bearing	Number	Percentage
Day 2	9	26.47
Day 1	5	14.71
Day 5	5	14.71
Day 3	7	20.59
Day 7	2	5.88
Day 4	4	11.76
Day 6	2	5.88

All patients were encouraged to walk from the first post operative day especially in the early three days of the week. Average weight bearing was done on 3.27 days.

Table 15: profile of complications

Complications	Number of patients	Percentage
Le	32	94.12
Pain at # site	11	32.35
Knee stiffness	3	8.82
Pain at pin skin interface	2	5.88
Ankle stiffness	4	11.76
Pain at corticotomy site	2	5.88
Varus deformity of leg	1	2.94

Table 16: profile of follow up observations

Follow up observations	Number	Percentage
Nil	18	52.94
Delayed union	3	8.82
Grade ii pin tract inf	5	14.71
Non union	3	8.82
Grade i pin tract inf	3	8.82
Lld-2 cm	1	2.94
Malunion	1	2.94

In our study, pin tract infection were common with 3(8.8%)case of grade 1 and 5(14.7%) cases of grade 2.
Delayed union and non union cases were 3(8.8%) each.
LLD of 2 cms and malunion in 1(2.9%) case each.

Table 17: Profile of Fracture Union

Fracture union	Number	Percentage
Y	31	91.18
N	3	8.82

In 31 patients, fracture got united and in 3 patient fracture went into non-union.

Table 18: profile of time taken for frame removal

Frame removal	Weeks
Maximum duration	40
Minimum duration	17
Mean	22.76

Table 19: profile of time taken for follow up

Follow up period	Months
Maximum follow up	30
Minimum follow up	12
Mean follow up	18.17

Mean fixator removal time was 22.76 weeks and Mean follow up time is 18.17 months.

Table 20: profile of johner and wruh's[5] criteria for final evaluation

J & w criteria	Number	Percentage
Excellent	28	82.35
Good	2	5.88
Poor	3	8.82
Fair	1	2.94

According to Johner and Wruh's criteria, 28 patient had excellent result, 2 patient had good result, 3 had poor and 1 had fair result.

Discussion

In this study, all the patient were from the active age group. Maximum age was 54 years and minimum age was 19 with a mean age of 37.74. Out of this 34 patients, 24 (70.6%) were males and 10 (29.6%) were females. In R. jan *et al* [6], 50 patients were studied out of which 43(86%) males and 7(14%) females. This study shows higher incidence of open injuries in males population in comparison of females suggesting a relationship between incidence and activity of the affected population. Since male population are more involved in outdoor activities, they are exposed to open fractures. Also in court brown *et al* [9], there were 230 patients and 76% of them occur in males population.
According to modified Gustilo Anderson classification [3], we have included only type IIIA and IIIB. Among 34 patients, 15(44.1%) were type b and 19(55.9%) were type a.

Table 21: comparison of number of gustilo anderson types in different studies

Study	Total patients	Type i	Type ii	Type iiia	Type iiib
Wani *et al* [2]	60	-	11	13	36
R jan *et al* [6]	50	-	17	20	13
Shtarker *et al* [8]	32	11	10	8	3
Ozturkmen *et al* [9]	33	8	12	13(combined type iiia and iiib	

In our study, 22(64.8%) were due to road traffic accidents and others 10(35.2%) were due to fall of heavy object. Of the road traffic accidents, 2 wheeler accidents (n=18) followed by pedestrian accidents (n=4) and 4 wheeler accidents (n=2) in order. Findings were similar to the standard studies of court brown *et al*. [7]
In our study, distal 1/3 fractures (n=13) were commonest followed by middle 1/3(n=11) and proximal 1/3 fractures (n=10). Subcutaneous location of distal and middle 1/3 diaphysis tibia predisposes it to open injury. Also precarious blood supply to distal 1/3 tibia increases the chances of nonunion. Hence these factors favour the use of ilizarov method to decrease the chance of non union, thereby reduces the morbidity of the patient.

Table 22: comparison of different level of fracture in different studies

Study	Total patients	Proximal 1/3	Middle 1/3	Distal 1/3
Wani *et al* [2]	60	12	27	12
Siddharthan *et al* [10]	42	21	17	3

In our study, we had 33% of comminuted fracture, 26.5% transverse fracture, 20.6% segmental fracture, 14.7% oblique fracture and 2.9% spiral fracture. 83.33% comminuted fracture united whereas 95.45% non-comminuted fracture united.
In our study, 22 patients had no bone loss whereas 12 patient

patients had upto 6 cms of bone loss. 6 patient had 2 cms of bone loss whereas 4 had 3 cms and 3 patient had 1, 5 and 6 cms of bone loss each.

In our study, all patients underwent 100% primary wound debridement prior to definitive surgery, 26 (76.5%) patient underwent primary ilizarov external fixator, whereas 8 patient with extensive soft tissue involvement or non-availability of ilizarov fixator underwent other method of temporary fixation. They were converted to ilizarov fixation secondarily. among 8 patients, 3(8.8%) had hybrid, 3(8.8%) had monoplanar fixator each and 2(5.9%) had biplanar fixator.

In our study, 64.7% of the cases underwent acute docking whereas 5.9% of the patient had acute docking with shortening. 29.4% of the cases required corticotomy and 52.9% required primary autologous iliac bone grafting in 79.4% of the cases ilizarov fixator with 4-ring construct was used as against 6 ring construct in 20.6% of the cases. 6 rings were used in segmental fracture. Bone grafting was done in patients with bone loss and in certain cases to augment healing.

In our study, split skin grafting was done in 25(73.5%) patients whereas local rotational flap was used in 5(14.8%) patients, 2(5.9%) patients secondary healing was achieved and in remaining 2(5.9%) patients, primary closure was done. Local rotation flaps of medial gastrocnemius and soleus were used with excellent results. flaps were done by general surgery team trained in plastic surgery.

In this study, 16 patients required second procedure, 6 patient required secondary debridement for infective compound wound and 4 needed wire tensioning. 3 patient needed realignment with frame adjustment. Loss of reduction was due to full weight bearing in immediate post-operative period. Secondary bone grafting was done in 1 patient. Recorticotomy was done in 2 patient.

In this study, all patient were non weight bearing on day 0. Then weight bearing was started from day 1 onwards as tolerated by the patient. 21 patients started weight bearing in 1-3 days and remaining within 7 days.

In our study, 33(91.2%) fracture united whereas non-union occured in 3 of the cases.

In our study, Maximum fixator time was 40 weeks and Minimum fixator time 17 weeks with a mean fixator time of 22.76 weeks.

Table 23: comparison of fixator time removal in different studies

R Jan *et al* [6]	18.3 weeks
Nesari *et al* [11]	19.1 weeks
Tucker *et al* [1]	26 weeks
Kumar *et al* [12]	27.7 weeks
Wani *et al* [2]	29.1 weeks
Our study	22.76 weeks

In our study, Maximum follow up for the patient 30 months and minimum follow up is 12 months with an average follow up is 18.17 months.

At the final follow up, results of the tibial shaft fractures were assessed by Johner and Wruh's criteria [5].

Table 24: comparison of result of johner and wruh's criteria in different studies

	Excellent	Good	Fair	Poor
Wani *et al* [2]	48	10	2	0
Our study	28	2	1	3

Conclusion

It is recommended to use llizarov external ring fixator apparatus to provide primary definitive fixation for high energy long bone fractures. Early weight bearing even in severely comminuted fractures is the key factor that separates it from other methods of fixation. lt promotes early functional recovery, eliminating fracture disease. Dynamization and correction of deformities in any plane is easily accomplished. Frame constructs can be modified to facilitate wound cover and access. Therefore it lands the much needed flexibility in complex fractures. Corticotomy, acute docking and lengthening allows removing the dead necrotic bone ends and correction of limb length discrepancy by distraction at corticotomy site.

Since this being a pilot study with a small sample (N: 34). Further studies with larger sample sizes and longer follow ups are recommended.

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