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SUBPERIOSTEAL SLIDE AS A NEW MANAGEMENT APPROACH FOR COMPOUND TIBIAL FRACTURES

Plastic Surgery

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ABSTRACT

Background: Motorcycle accidents constitute upto 20% of road accidents in India. Lower limb trauma occurs in half of them with Gustilo III fractures showing a rise. Reconstruction requires stable soft tissue cover over aligned fractures. Morbidity results from poor tissue cover, osteomyelitis and non-union. Despite evidence, few surgical approaches succeed in addressing the need for periosteal cover. This approach provides vascularized periosteal cover at fracture sites to promote bone healing, without sacrifice of muscle / neurovascular structures or function.

Methods: 22 patients comprising 21 Gustilo III B cases of open tibial fractures were included. All underwent a vascularized periosteal flap cover for the exposed fracture. This was achieved by employing composite myoperiosteal, periosteocompartment or periosteomusculocutaneous slide. Residual cover was completed by split skin grafting or perforator plus flaps.

Results: Fractures were segemental or distributed across all thirds of tibial shaft. Bony and soft tissue cover was achieved in all employing subperiosteally elevated sliding muscle flaps and perforator-based flaps respectively. Early results were assessed at 4 weeks with follow up up to 2 years. Healing of fractures and stable cover was achieved in 16 cases. Bony union was evident in another 3 despite osteomyelitis. The remaining 3 patients with intramedullary nails had endosteal infection and non-union.

Conclusions: Current approach to managing compound leg fractures stresses need for vascularized stable soft tissue cover while bony union is considered to occur by default. Experimental evidence of improved fracture healing using vascularized periosteum has rarely been translated to clinical studies. Vascular periosteal flaps based on muscle pedicles are a viable, easily executed and safe option and help in bone regeneration. Well perfused periosteal bone and soft tissue cover, both are achievable by this approach.

KEYWORDS

Compound tibial fractures; subperiosteal muscle slide flaps; vascularised periosteal cover

Introduction

More people die in road accidents in India than anywhere else in the world. Motorcycles cause 22% of all road accidents with lower limb trauma occurring in 50% of these.[1] Our referrals of Gustillo III fractures have doubled in the last 5 years to average three per month presently.

The goals of definitive treatment of lower limb trauma include wound coverage; prevention of infection; restoration of length, alignment, rotation, and stability; fracture healing; and return of function.[2] Soft tissue cover for an exposed fracture tibia of any extent / location rarely poses problems to plastic surgeons, given the available options. A vascularized cover for exposed bone and fracture site is acknowledged as a necessity to allow healing, with both muscle and fasciocutaneous flaps(local/free) being employed for the same.[3] Central to underlying bone healing is the important need for vascularized periosteal cover over injured bone.[4] Despite evidence, presently few operative approaches address this critical need to provide viable periosteal cover over fractured denuded bone.

The present technique is based on established physiologic and surgical principles and achieves cover over injured denuded bone using viable periosteum. This is accomplished by performing subperiosteal dissection and mobilization of muscle as carrier. The periosteum with the overlying individual muscles/ compartment is dissected from healthy bone, shifted and slid to cover denuded cortex.[5] This periosteum retains its vascularity through the intact muscles and their preserved blood supply. Composite periosteal, muscle and skin slide has also been used en masse.

After achieving a primary vascularized myoperiosteal bone cover over the fracture site, the secondary soft tissue cover, if needed, is achieved by appropriate means. This includes split skin grafting over healthy muscle or locoregional tissue flaps. This is based on availability of loco regional soft tissues while aiming to minimizing collateral morbidity.[6] In this series 22 patients of lower limb trauma operated by this approach are presented. Early and long term follow up with complications were analysed and variations of approach to maximize benefits are discussed.

Patients and Methods

22 patients with lower limb trauma and exposed bone / hardware (21 Gustilo III b fractures) underwent this procedure from Aug 2005 to Oct 2011 at tertiary care reconstructive centres by a single operator. One case had shin degloving with exposed Tibia bereft of periosteum without a fracture. There were 20 men and 2 women in the group. Patients requiring only skin grafting or those with vascular trauma were excluded.

The patient's age ranged between 19 and 73 years (mean, 38 years). The time of referral since date of injury ranged between 8 and 290 days (mean, 59 days). There was one diabetic, 3 hypertensives and 3 chronic tobacco chewers. 7 cases had polytrauma which was managed and patients stabilized prior to referral. All had evidence of significant wound infection with slough. The exposed bone was bereft of periosteum in all cases with variable periosteal loss over the surrounding zone. Of 11 patients with bone loss ranging from 1 -11 cm, 7 had undergone bone grafting prior to referral. Cases were referred for reconstructive management after debridements, attempts at primary closure and bone grafting by orthopaedic colleagues.

Soft tissue defects were from 4.5 cm sq. to 245 cm sq. while tibia exposure ranged from 4 cm sq. to 102 cm sq. Following referral to our centre, patients underwent definitive reconstruction after 2 to 30 days (mean, 10.3 days). Four patients with severe infection and frank purulent discharge underwent vacuum assisted dressings till the wound bed was clean.

3 patients with narrow defects underwent a composite skin muscle periosteal compartment slide and direct closure was achieved without creation of a secondary defect. In 2 cases, cover was achieved by using bipedicle subperiosteal musculocutaneous flaps and grafting of the secondary defect while another 2 required a muscle slide followed by SSG since there was significant overlying skin loss. In the remaining 15 patients a subperiosteal muscle slide was done followed by a perforator based fasciocutaneous transposition flap. This was either slid or rotated into the defect. Perforator inputs to these flaps were preserved in all cases, while subcutaneous neurovascular inputs were safeguarded.

Surgical Technique

Thorough debridement was done in all, with curettage and excision of slough. Exposed non-viable bone was shaved and loose fragments removed. The tibia was approached through the wound with the incision extended vertically along the shaft above and below the defect till the subperiosteal bone. The periosteum was elevated around the fracture and adjoining tibial shaft without disturbing the origins of the entire overlying muscle compartments. This prevented damage to intra compartment structures since the dissection remained completely subperiosteal over bare bone. The circumference of periosteum with

the overlying muscle compartments, adipofascia and skin was raised en masse over the denuded tibia. A vertical incision was now made in the elevated posterior periosteum in the midline. Blunt splitting of this periosteum and posterior compartment muscles was done using a scissor. This allowed mobilization and rotation of the entire soft tissue bilaterally around the degloved bone. No attempt was made to dissect between the muscles, adipofascia or skin unless closure was not feasible. This approach shifted the location of compartment originating from posterior to more anterior aspect over denuded bone. 1-2 perforated suction tube drains were placed posterior to the tibia and in the soft tissue as appropriate. Once successful musculoperiosteal closure was ascertained 1-0 Polyglactin/ Polydioxanone were taken from the edges, progressively closing towards the centre. Wide horizontal mattress periosteal and muscle edge sutures with buried knots were employed while assistant aided in keeping the flaps opposed. A limited dissection of 1cm was done between the fasciocutaneous edge and underlying muscle to allow suturing in layers. Primary fascia and skin closure was accomplished safely if there was minimal loss (Fig 1). If closure appeared to be under undue tension, a split thickness graft was applied over the muscle closure and graft stapled to the skin edge (Fig 2).

Alternately, in the lower third leg, unilateral or bilateral fasciocutaneous bipedicle flaps permit skin to slide centrally to buttress the tibial defect. Limited separation from the underlying muscles was done till tensionless closure was achieved. The tibioperoneal perforators were safeguarded while elevating these flaps. In 15 cases we limited subperiosteal circumferential dissection to immediately around the injury site. Once the denuded bone was covered by the muscle periosteal flap a local perforator based fasciocutaneous flap was fashioned and inset over the injury site. Neurovascular inputs to this sliding fasciocutaneous flap and crossing it for distal supply were preserved (Fig 3). Seconday fasciocutaneous flaps were also be rotated after periosteal bone cover, with split skin graft over the resultant defect (Fig 4). At the proximal wide tibial end, both the anterior and posterior compartments needed subperiosteal elevation to allow enough mobilization to cover exposed bone or hardware (Fig 5).

A cohesive crepe bandage was given post operatively with the limb kept in elevation for 2-3 days; the crepe support was continued for two weeks or till the skin healed well. Suction drainage was continued on required basis for a few days. The wound was inspected at 48 hrs and dressings changed. Limb vascularity was monitored by clinical pulsation and SpO2 in all cases but was never compromised. Active muscle movements were encouraged after a week while ambulation depend on orthopaedic parameters.

Figure 1. (Above, left) Shin defect with exposed hardware and fracture. (Above ,right) The loose bone graft is evident . Subperiosteal dissection has been completed over the anterior and medial compartment. (Below,left) Following a posterior periosteal incision, mobilization of the compartments results in periosteal and skin closure. (Below, right) 2 weeks post operative with healing. No secondary defect or additional incisions without any neural,vascular or muscle defecit .

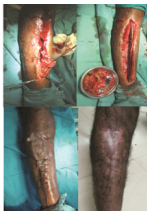

Figure 2. (Above,left) 60 day after tibial plating with extensive sepsis and slough of anterior compartment. (Above,right) Thorough debridement with 10 cm plate exposed and subperiosteal muscle dissection.(Below,left) Complete musculoperiosteal closure achieved with 80% skin closure.A strip of skin graft is placed over the superior edge. (Below, right) 8 months post operative with fracture healing and no osteomyelitis.

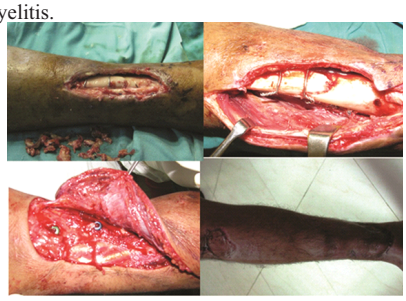

Figure 3. (Above,left) Segmental fracture involving all thirds of tibia and 4.5x 1 cm exposed bone and hardware lower third. Defect following debridement. (Above ,right) Anterior compartment subperiosteal release. (Below ,left) A lateral fasciocutaneous sliding transposition flap preserving subcutaneous neurovascular structures.(Below,right) Healed flap with stable cover at 3 months with no osteomyelitis/ sinus.

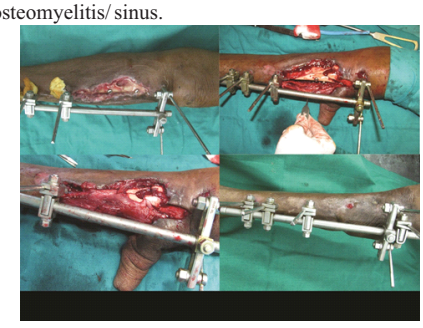

Figure 4. (Above,left) 3 weeks old comminuted fracture in a 73 yr man involving proximal tibia. There is evidence of sepsis following ORIF and bone graft. (Above,right) Debridement, anterior compartment subperiosteal slide and elevation of fasciocutaneous transposition flap. (Below ,left) A major extent of exposed Tibia has been covered by the muscle slide. The fasciocutaneous flap was rotated to cover the apex and buttress the muscle slide.(Below,right) 3 months post operative , there is an osteomyelitis sinus. The fracture united without further intervention.

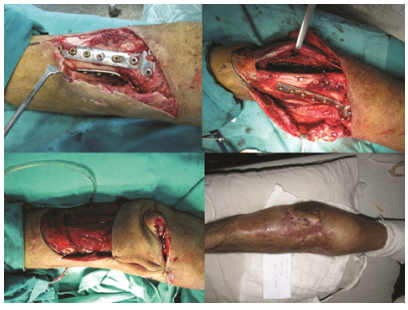

Figure 5. (Above,left)One month old comminuted Tibial plateau fracture with buttress plates and bone graft. Post debridement image. (Above,right) Subperiosteal anterior and posterior compartment slide with adequate mobilization for cover. (Below, left) Periosteal suturing to cover bone and hardware along with fasciocutaneous rotation for apex buttress.(Below,right) 4 months post operative.Despite marginal fasciocutaneous flap necrosis and local transposition flap one month post op, stable cover with no osteomyelitis. The fracture united and the patient is ambulant.

RESULTS

19 cases had injuries related to motorcycle accidents, 17 while driving and 2 as pedestrians. One patient was hit by a car and another 2 suffered fractures due to crush/fall. Of the 2 women, one was a pillion rider while the other was injured in a wall collapse. 9 patients had fractures involving the proximal third tibia, 7 had mid third injuries while 3 had distal involvement. 2 patients had multiple segmental fractures. The last remaining case had degloving of tibia and leg without fracture. All patients underwent surgery under spinal anaesthesia with operation times ranging from 75 to 135 min (mean,96 min).

Early results were tabulated 4 weeks post operatively. Complete flap healing was present in 14 patients. 4 had minor wound problems which

healed with dressings and conservative treatment. 1 patient required the application of stored graft while another needed resuturing due to flap detachment. Remaining 2 patients had residual bone exposure, one following a wide suture line dehiscence and another due to 1.5x1 cm apical necrosis of fasciocuaneous flap. Both needed salvage local fasciocutaneous flaps with successful stable cover. Late follow up was done from 6 months till 4 years. Stable soft tissue cover with fracture union was evident in 16 patients while osteomyelitis occurred in 6 cases. While fracture union proceeded in three of these, the remaining 3 with intramedullary nails developed endosteal infection with delayed union. They were managed by intramedullary nail removal, debridements and underwent Ilizarov ostegenesis. One patient needed a local fasciocutaneous flap cover 5 months after the initial surgery due to osteomyelitis and bone exposure.

To assess the duration of delay in definitive reconstruction on the outcome, the healed group was compared to the 6 cases with osteomyelitis. Patients without infection were operated on an average of 67 days post injury compared to 72 days for the osteomyelitis group which was not significant.

Table I: Patient and Injury profile. Surgical procedures, reconstructive outcomes at 4 weeks and 6 months, orthopedic outcomes at 1 year and functional status of patients at 2 years postoperative follow up are

S No	Age	Fracture site (thirds)	Bone exposed	Soft tissue defect	Time to referral (Days)	Flap used	OT time (min)	Early outcome of reconstruction (4 weeks)	Reconstruction outcome at 6 months	Orthopedic outcome at 1 year	Functional outcome at 2 years(Grade)
1	22	Nil	16x2	2/3 leg circumference	45	SPS*	125+30	Partial SSG loss, stored graft applied	Stable cover	No fracture	I
2	36	Middle	2.5x2.5	9x4.5	54	SPS+SSG	80	Healed	Stable cover	Fracture union	II
3	40	Proximal	11x3 with 12 cm bone loss	23x9	38	Gastrocnemius & SPS +SSG	130	Healed	Stable cover	Fracture union after bone graft	III
4	31	Middle	18x2.5 with 7.5cm IM nail exposed	22.5x7.5	51	SPS	110+35	Healed	Local transposition flap after 5 months for 1x1cm exposed bone.	Endosteal osteomyelitis. Bone graft	III
5	30	Proximal	2.5x2.5	4x3	25	SPS with Neurovascular preserving Transposition	95	Healed	Stable cover	Fracture union	I
6	58	Segmental	7x3 4.5x2.5	31x7	12	SPS + Transposition	135	Patchy graft loss. Conservative Rx	Stable cover	Malunion	III
7	29	Segmental	4.5x1	9x11 upper 9x1.5 lower	13	SPS+ Fasciocutaneous transposition Neurovascular preserving	75	Healed	Stable cover	Malunion	II
8	30	Distal	4.5x1 4cm IM nail exposed	7x2.5	290	SPS+ Perf based Neurovascular preserving transposition	110	Gaping of suture line. Conservatively treated	Stable cover with suture line sinus	Osteomyelitis sinus	III
9	26	Middle	9x4.5	13.5x5	16	SPS + Neurovascular preserving transposition	90	5 cm dehiscence. Resutured	Stable cover with suture line sinus	Osteomyelitis sinus	III
10	46	Proximal & middle	1x2 3x1.5 1cm IM nail exposed	1x2cm 15x4	24	SPS + Fasciocutaneous transposition	85	Healed	Stable cover	Fracture union.	II
11	27	Proximal & middle	4.5x1 3 screw head exposed	4.5x1	204	SPS	95	Healed	Stable cover	Fracture union.	II
12	23	Jn of proximal & middle	4.5x1.5	9x1.5	33	SPS	85	Healed	Multiple sinuses	Endosteal Osteomyelitis. Bone grafting.	III
13	19	Middle	6.5x4.5	9x7	15	SPS+ Fasciocutaneous transposition	90	Healed	Stable cover	Fracture union	II
14	41	Proximal	2x2	12x3	46	SPS	105	Healed	Stable cover	Fracture union	I
15	73	Proximal	11x3.5	18x7	22	SPS+ Fasciocutaneous transposition	90	Healed	Sinus	Osteomyelitis sinus. Fracture union	II

16	30	DIstal	29x3.5	35x7	8	SPS	125	50%Dehiscence	Reoptd twice employing local transposition and sural flaps. Multiple sinuses	Endosteal osteomyelitis.	III
17	31	Proximal	4.5x4.5	6.5x6.5	250	SPS + Fasciocutaneous transposition	80	Minimal gaping. Managed conservatively	Stable cover	Fracture union	II
18	47	Proximal	6x3	8x4	19	SPS + Fasciocutaneous transposition	80	Healed	Stable cover	Fracture union	II
19	46	Distal	7x2	13.5x9	30	SPS +Bipedicle	95	Wound gaping. Conservative Rx	Stable cover	Fracture union	II
20	28	Proximal	10x7	10x8	28	SPS+ Fasciocutaneous transposition	90	Partial necrosis. FC flap after 1 month	Stable cover	Fracture union	III
21	51	Proximal	2x3	4x4	36	SPS+ Fasciocutaneous slide	65	Healed	Stable cover	Fracture union	II
22	63	Proximal	5.5x3	6x5	46	SPS+ Fasciocutaneous Transposition	85	Healed	Stable cover	Fracture union	II

outlined (*Subperiosteal slide).

Discussion

Skin is the best and natural dressing for raw areas. Soft tissue closure without flaps is associated with deep infection in one-third of patients of Gustillo IIIB tibial fractures, requiring debridement and cover. Adequate debridement and flap cover is suggested in all cases, irrespective of age.[7]

Wound cover with sacrifice of important local or distant free muscles remains a frequent approach, notwithstanding the sacrifice of useful function.[8] In a cost benefit scenario, infrastructure and cost effectiveness become important deciding factors on which option to choose.[9]

The burgeoning workload of compound tibial fractures with polytrauma in our setup necessitated a comprehensive approach. For having an acceptable functional outcome patient need to be operated at the earliest, employing safe and effective procedures.[10] This needs to be accomplished with minimal of infrastructure load and time frame.[11]

Our centre is employing traditional, perforator based and microvascular free flaps in lower limb trauma. With polytrauma cases on the rise, an increasing number of tibial fractures are referred late following treatment of life threatening injuries. Ideally, development of specialist trauma centres is advocated for improving care.[12] Nevertheless, for the present, our patients are referred with gross local sepsis, osteomyelitis, dead necrotic bone and exposed hardware.

Being natural bone cover, periosteum initiates its formation after injury and studies attest to the same.[13] Orthotopically placed autologous nonvascularized periosteum retains its osteogenic potential even in an ischaemic environment, the effect being enhanced with graft contact to intact periosteum thus, justifying the use of free periosteum or flaps for fracture cover. The advantage of vascularized periosteal graft over avascular has been proved by better bone healing in the early stage.4 Histologically, callus formation after periosteal grafting resembles endochondral and intramembranous ossification. [14]

Evidence to the usefulness of vascularized periosteum in bone healing notwithstanding, surgical approaches to incorporate the same into practice are lacking. Based on the above evidence, we covered different tibial fracture sites by vascularized periosteum. The periosteum muscle interface is kept intact by employing a subperiosteal approach and this keeps the periosteum viable through muscle circulation. It also avoids the laborious fibrotic tissue and muscle dissection by remaining on the bone surface. Because subperiosteal dissection also does not diminish the blood flow in injured muscles, it seems to offer advantages as a surgical approach to bone in a severely traumatized extremity.[5] This seems to provides long term stable and successful bone cover while preserving muscle function and with minimal collateral morbidity.

Animal studies on fracture healing underline the importance of muscle-periosteal connection for periosteal healing of diaphyseal fractures.[15] Viable periosteal cover is accomplished without creating muscle damage in the injured limb by the subperiosteal approach.

Whitesaid evaluated the effect of sub and extraperiosteal dissection on fracture healing. Their data suggest that in the absence of muscle damage, subperiosteal dissection results in earlier healing than does extraperiosteal dissection. Muscle transection markedly retards healing; then, after transection, neither type of dissection appears to retard healing more than the other.[16]

Often entire local muscles or their segments are employed to cover bone due to a prevalent view of increasing blood supply at the fracture site.[17] Late operations are rendered difficult due to inflammatory fibrosis and atrophy which obliterate tissue planes. Despite evidence that muscle sacrifice appears to retard fracture healing, these approaches are commonly employed. The subperiosteal approach enables cover of injured bone by shifting muscle origins over bone shaft. Post-operative results show active muscle contractions at the transposed location with preserved function. The minimal change in direction of muscle axis makes little discernable difference to function due to preserved retinaculum maintaining directional force.

Muscle and fasciocutaneous free flaps are reliable in expert hands but need microvascular training, are equipment intensive and time consuming. There is a perception of their overzealous use over simpler and cost effective locoregional options.[18] Perforator flaps or their pedicled 'plus' variants offer simpler functional options for successful cover to subcutaneous tibia.[19,20] Rezende considers perforator flaps as an effective alternative option to free microsurgical flaps.[19]

Despite providing safe soft tissue cover, none of these flaps provide any inducement to bone healing. Many need meticulous dissection to protect neurovascular bundles and close postoperative monitoring due to vascular complication rates of 7% .[21] The subperiosteal approach does not adversely affect the vascular supply of muscles, fascia or skin and does not need any post-operative vascular monitoring. Since periosteal sutures take the tension off the skin, there is minimal risk of skin necrosis as evident in this series. Dissection is rapid without sacrifice of any tissue. Closure under tension can also be avoided by

transposing individual subperiosteally dissected muscles over the denuded bone or fracture site rather than shifting the entire compartment.

Current surgical approaches cover exposed fractures employing soft tissue with various grades of vascularity but no osteogenic potential to aid union. Subperiosteal slide shifts healthy osteogenic periosteum from involved tibial shaft to denuded bone. The axial neurovascular bundles are left undisturbed without compromise. This ensures cover of bone by viable perfused periosteum and aids bone and soft tissue healing. There is no sensory motor loss and muscle function is preserved. In selected cases no secondary defects are created with no need for grafting.

Follow up clinically and radiologically over 6 months to upto 4 years revealed sound union with stable cover. The posterior surface of tibia from where the periosteum is effaced effectively regenerates and no bony abnormality is obvious on follow up X- rays taken up to 2 years post operatively.

Delayed cover has been reported to result in about 20% of cases developing osteomyelitis on just 10 months follow up. There are evidence-based guidelines which suggest that aggressive debridement and soft tissue cover within 3-5 days reduces complications and delayed union. [22] In our series the earliest referral was 8 days following trauma and only 5 patients were referred within 3 weeks of injury. All the referred cases had infected wounds with slough and necrotic bone. Aggressive debridements and definitive reconstructive cover was provided on an average of 10.3 days post referral. However, the overall duration of surgery post injury was significantly late, averaging 69 days. Follow up revealed that 6 patients (27%) had osteomyelitis of which three patients had a single intermittent discharging sinus. Fractures in this group progressed to union on conservative treatment. The remaining 3 had multiple sinuses with delayed union. One has undergone debridement and bone grafting while the other two are under orthopaedic follow up. The significant delay prior to reconstructive referral negates any advantages of 'early' flap cover on receiving the patients. The usefulness of this approach is likely to be more evident if intervention is done earlier, which requires close orthopaedic and plastic surgeon's cooperation and further evaluation.

Single stage orthoplastic reconstruction of Gustilo III open fractures greatly reduces infection rates from 34.6% deep infection if operated in stages compared to only 4.2% if operated in one orthoplastic combined stage.[23] In our study all patients were operated in multiple stages with definitive reconstructive operations performed on an average of 69 days post injury. With deep infection rate of 27%, our study may compare favourably with reported series. An ideal situation would envisage provision of stable sensate cover without sacrifice of muscle function, nerve or blood supply while maintaining aesthesis. A physiologic procedure without need for extensive infrastructure or special training is desirable. Cost effectiveness also dictates short operative duration in a single stage operation. The coming years may see aggressive single stage early orthoplastic team operatives in these difficult fractures. Though a utopian order, the subperiosteal compartment slide may successfully contribute on the above parameters.

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