Review article

Comprehensive review of challenges associated with management of lower limb fractures in poliomyelitis patients

Mayank Gupta, Vijay Kumar Jain*, Gaurav Kumar Upadhyaya, Rajendra Kumar Arya

Department of Orthopedics, PGIMER Dr Ram Manohar Lohia Hospital, New Delhi, India

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ABSTRACT

Poliomyelitis is on the verge of eradication. But the survivors of polio are still living with its consequences in different parts of the world and so will continue to be seen for almost a century. Fractures in the polio-affected limb are a common entity in these patients and are difficult to manage using the common fracture management protocols. This article gives a comprehensive review of the challenges faced in fixation of fractures in polio affected limbs and possible solutions to overcome them. Knowledge of treating these fractures is important to a trauma surgeon as such scenarios are not uncommon in daily practice.

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Introduction

Poliomyelitis is caused by a neurotropic virus which targets the anterior horn cells of the spinal cord resulting in asymmetrical flaccid paralysis.¹ Poliomyelitis is on the verge of eradication from most of the parts of the world.¹ Though in developed and most of the developing countries it has been eradicated, some developing countries are still reporting new cases.¹ Therefore survivors of acute illness with post-polio residual paralysis are still commonly found in orthopedic clinics, both in developed and especially in developing countries. An estimated population of 10–20 million people in the world is living with consequences of polio and around 6.5 million of them are in India.^{1–3} In the developed countries polio survivors have lived through their life and crossed 40–50 years of age due to the eradication of polio much earlier but in developing countries they are still young.¹ So managing both young and old patients with fractures in poliotic limbs has to be taken into consideration.

Falls and subsequent fractures are common in these patients, which are difficult to manage and cause considerable morbidity. A thorough clinical knowledge is essential to be known to all orthopedic surgeons who are involved in the management of such patients for treatment of such fractures as a considerable number present in emergency services. We present here a comprehensive

review of challenges associated with management of lower limb fractures in poliomyelitis patients.

We have found limited published literature pertaining to fractures and their management in polio patients and no such review article to address such injuries. A search was made on PubMed using keywords 'polio' and 'fracture' and the appropriate relevant articles were selected for review. We have tried to give some solutions based on published literature and our own experience to manage such patients to give good functional outcome.

1. Falls and fractures in polio

Poliomyelitis being primarily a disease of the motor system leads to flaccid asymmetric paralysis and muscle atrophy which reduces stability, mobility, alters the gait pattern and hence predisposes to falls (Fig. 1).⁴ Muscle paralysis in polio can be in the residual form of the acute illness known as post-polio residual paralysis or due to development of post-polio syndrome (PPS).³ Falls generally occur during ambulation. There are several contributing mechanisms. The preponderance of lower limb involvement in polio, especially quadriceps weakness is itself a risk factor for falls and hence fractures. Knee buckling due to quadriceps weakness during stance phase and failure to clear the foot off the ground in swing phase due to ankle dorsiflexor or hip flexor paralysis frequently leads to falls.³ In addition, the gait is imbalanced in these patients due to deformities, contractures, limb length discrepancies and improper distribution of muscle forces.⁵

It has been found by Bickerstaffe et al. that the frequency of falls in polio patients is four times higher than the general population.

* Corresponding author at: Department of Orthopedics, PGIMER Dr Ram Manohar Lohia Hospital, New Delhi 110001, India.
 E-mail address: drvijayortho@gmail.com (V.K. Jain).

Fig. 1. Anteroposterior radiograph of pelvis showing fracture neck femur in the left sided poliottic limb. The other side had already been fixed about 2 years back for an intertrochanteric fracture. Patient is a frequent faller predisposing to fractures of the poliottic as well as normal limb.

Also there is a higher frequency of recurrent falls and falls in elderly polio patients. 50–84% of polio patients have at least one fall per year which is higher than the yearly rate of falls in normal elderly people of more than 55 years of age (17–23%).³ One study shows that 61% of 233 polio participants had required medical attention at some point as a result of a past fall and 35% had sustained a fracture.⁶

Although fractures can occur anywhere in poliottic limb, low-energy proximal shaft, and distal femoral fractures are more common.⁷ Recently Goerss et al. conducted a study on 277 polio survivors and found that the incidence of any fracture after 40 years of age was 48% and the cumulative incidence of any limb fracture was 41%. The risk of distal femoral and proximal humeral fractures was significantly higher. Authors concluded that the survivors of polio do not have an unusual risk of fracture except in affected limbs.^{7,8}

2. Polio and osteoporosis

The exact prevalence of osteoporosis in polio patients is not known but it has been found that poliomyelitis is a risk factor for regional osteoporosis.^{4,9} The frequency of osteopenia and osteoporosis are higher in the polio affected limbs as compared to the general population. According to one study 96% of polio patients had osteopenia and osteoporosis and reported a fracture incidence of 38% over 5 years.³ The site most commonly affected by osteoporosis in such cases is usually the hip in lower extremity involvement.⁴ Chang et al. found that the femoral neck bone mineral density (BMD) was lower both in normal and affected limb in polio patients as compared to age-matched controls; though the paralyzed side was more osteopenic than the normal one.¹⁰

The risk of fracture increases 1.5–3-folds for each standard deviation (SD) decline in BMD, with hip fractures most closely linked to BMD than other osteoporotic fractures.⁴ The lifetime risk of sustaining a proximal femur fracture rises with the decrease in BMD. Also there exists a significant correlation between bone mass and muscle strength.⁴ Reduced total lean muscle mass is an important contributing risk factor. So polio affected limbs, specially the non-weight bearing ones, have a lower BMD than rest of the skeleton and this predisposes them to fractures with any sort of trivial or significant trauma.

Therefore these patients should be evaluated for BMD in the affected limb to determine the presence of osteopenia at an early stage and appropriate therapy should be instituted. This can reduce the incidence of a subsequent fracture in these patients, hence decreasing ensuing morbidity and mortality.⁴ Bisphosphonates, known to be beneficial in decreasing the fracture risk in osteoporosis, have a similar effect in polio patients.¹¹ Alvarez et al. have found oral bisphosphonates to be effective in increasing the hip BMD in polio patients and the effect being similar when compared to normal controls.¹² Also they showed that the treated patients had a lower fracture risk than the non-treated polio patients. Other preventive measures include calcium and vitamin D supplementation, safety and fall prevention strategies with muscle strengthening and balance training, deformity correction, contractures releases, appropriate assistive devices and braces and home and work modifications.¹¹

3. Polio and bone healing

Fracture healing progresses at a normal rate in bones of poliottic limbs. The callus forms normally and in the expected time frame.¹³ Poliomyelitis does not predispose to increased risk of excessive callus formation or heterotopic new bone formation after trauma.¹⁴

4. Polio and fracture management

It is difficult to achieve pre-injury ambulatory status in these patients after fracture.⁷ Long period of immobilization and non-weight bearing contribute to worse prognosis in post-polio patients with fractures.^{8,9} In addition despite the best surgical efforts hardware failure and subsequent reoperation rate is high in these cases. The aim of the treatment of fractures in polio patients should be achieving early union, early mobilization and rehabilitation to prevent joint contractures and further muscle wasting. A team work of orthopedics surgeon, orthotist, and physiotherapist and occupation therapist is paramount to give good functional results in polio patients with fracture (Table 1).

4.1. Conservative treatment

There are few studies which describe the conservative treatment in the form of traction, bracing and casting for fractures in polio patients with good results.¹⁴ But conservative treatment has its own associated risks of malunion, joint contractures and pressure sores.¹⁵ Conservative management predisposes to further reduction in mobility of the patient, increasing loss of muscle mass and strength and osteoporosis of the already porotic bones in addition to the other known hazards of prolonged recumbency.

4.2. Operative treatment

The indications of internal fixation are almost the same as for non-polio patients. Fracture fixation in polio patients is a challenging job. The bones of the affected limb are often hypoplastic, deformed, osteoporotic, together with paralyzed

Table 1

Summarizes some of the points with regards to fractures in polio patients.

Polio and fractures
<ul style="list-style-type: none"> • Polio predisposes to falls • Proximal femur fractures common • Osteoporosis increases the risk • Fractures show normal healing • Difficult to manage

Fig. 2. (A and B) Anteroposterior and lateral radiographs of a polio patient with fracture neck femur which was fixed with three cannulated cancellous screws. This figure illustrates how excessive valgoid, anteverted and small neck has led to improper screw placement; though the fracture has united.

and less vascularized muscle envelope.¹⁵ The difficulties encountered and possible solutions with various commonly used implants are described below.

4.2.1. Cannulated hip screws

Incidence of fracture neck of femur in polio survivors is not much reported in literature.¹⁶ Unique problems here included are altered bony anatomy affecting reduction and conventional implant placement. Paralytic hips are associated with excessive anteversion, valgus neck and small neck which may pose difficulties in fixation of femoral neck fractures.¹⁶ Excessive anteversion may require excessive internal rotation to achieve a closed reduction and an unusually sited posterior entry point close to the buttock to negotiate a guide wire into the neck. The addition of extreme valgus or varus may further complicate the already difficult situation requiring unusual abduction or adduction. These anatomical variations should be kept in mind before deciding for fixation of such fractures. A perfect triangular relationship may not be possible to obtain because of small neck (Fig. 2A and B).¹⁶ The screw sizes as well as number required may be smaller as compared to a healthy patient of same age.

Nonunion of hip fractures can be even more difficult in these cases and requires revision surgery.¹⁷ Revision surgeries in the form of osteotomies, muscle pedicle grafts or arthroplasties become more challenging in these cases with a high failure rate and the risk of requiring multiple surgeries.¹⁷ Spinnickie et al. described a case of nonunion of intertrochanteric fracture in poliotic limb of an elderly patient treated with constrained total

hip arthroplasty (THA).¹⁸ Abductors and extensors of hip are weak, hence decision of constrained THA reduces the chances of postoperative dislocations (Table 2).

4.2.2. Intramedullary nails

Patients with polio have narrow intramedullary canals which make the insertion of standard sized nails difficult after a fracture.¹⁹ Also because of the limb length discrepancy, determining the correct nail length preoperatively using the normal limb as a standard is not possible. Access to correct entry points is hampered by the presence of bony deformities and various fixed contractures and deformities of the joints as well.¹⁵ In some cases with extreme bony distortions intramedullary devices may not be the option at all for fixation.

Long bones of polio patients may be viewed akin to the paediatric bones with narrow intramedullary canals. This makes the use of elastic nails like titanium elastic nailing system (TENS), or even two Rush pins used generally for paediatric patients, a reasonable option in poliotic bones.^{20,21} Though elastic nail aligns the fracture fragments, rotational instability remains a concern and in these cases bracing support may be advisable (Figs. 3 and 4A and B).

Positioning the patient over a traction table for nailing is also difficult due to the presence of joint deformities and contractures. It might not be possible to use the traction piece for reduction because of flexion abduction deformity in hip and flexion deformity in knee, which are common in these patients. The patient can be operated in supine or lateral position depending upon the comfort of surgeon, implant selection, presence of deformity at hip and knee.¹⁵

The deformity at the fracture site is usually less compared to the non-polio patients due to lack of muscle spasticity and poor muscle bulk. Hence manual traction is sufficient to align the fracture. Reduction can be achieved with gentle manual traction in different degrees of knee flexion. Strong traction should be avoided in flaccid limb of polio patients as it may result in over distraction or displacement of fracture fragments.¹⁵

The above-mentioned challenges with intramedullary nails can be overcome by the use of external fixators or plates described below (Table 3).

Table 2

Hip fractures in polio patients.

- Higher incidence
- Difficult reduction and fixation
- Small, valgoid, anteverted femoral necks
- More chances of nonunion and implant failure
- Dynamic hip screw or cannulated cancellous screw fixation may not be possible in every case
- May require proximal femur locking plates or rarely external fixators
- Nonunions very difficult to manage
- Limited arthroplasty options due to altered anatomy, paralyzed limbs, contractures, etc.

Fig. 3. A 50-year-old lady presented with a peri-implant fracture of femoral shaft in a poliotic limb which was initially fixed with a plate. There is marked flexion deformity at hip and knee joint.

4.2.3. External fixator

Catagni et al. have successfully used external fixator for the fixation of proximal femoral fractures in which insertion of

Table 3

Summarizes various aspects pertaining to nailing.

Polio and intramedullary nailing
Pros <ul style="list-style-type: none"> • Reduction easier with minimum traction • Minimally invasive • Less blood loss • Fracture haematoma preserved • No periosteal stripping • Load bearing device
Cons <ul style="list-style-type: none"> • Narrow and distorted canals • Access to entry point difficult • High chances of converting to an open nailing procedure • Difficulty in patient positioning over fracture table • Limb-length discrepancy • Unavailability of very small nail sizes
Solutions <ul style="list-style-type: none"> • Use of elastic nails e.g. TENS • Customized nails using Computer Assisted Designing • Use of locking plates • Use of external fixators

intramedullary nails was difficult due to narrow intramedullary canals.²² As compared to internal fixation, external fixation is less traumatic and with negligible additional blood loss. Also a wide range of freedom is available to the surgeon to place the pins at different angles in narrow and deformed femoral necks. Similar to a proximal femoral fracture this discussion also holds true for various other limb fractures in polio patients. The disadvantage of external fixation is that it can be very cumbersome especially if the adduction deformity of contralateral hip is also present. In addition the relative weight of the fixator is problematic. Pin track infection and muscles fixations by pins may add to further fibrosis and muscles contractures (Table 4).

Fig. 4. (A and B) Antero-posterior and Lateral radiographs of the same patient after treatment with plate removal, open reduction of femoral shaft fracture and internal fixation using two TENS nails. Note the narrow intramedullary canal made the insertion of even minimum sized interlocking nail impossible.

Table 4

Summarizes various aspects pertaining to external fixation.

Polio and external fixators
Pros
<ul style="list-style-type: none"> • Wide range of applicability at almost all sites • Less invasive • Negligible blood loss
Cons
<ul style="list-style-type: none"> • Application difficult in deformed bones, contractures • Pin tack infection • High chances of nonunion
Solutions
<ul style="list-style-type: none"> • Use of Ilizarov fixators • Use of multiplanar fixators

Table 5

Summarizes various aspects pertaining to plating.

Polio and plating
Pros
<ul style="list-style-type: none"> • Applicable to any site in bone like metaphysis or diaphysis • Applicable in deformed and narrow bones • Allow greater variation in technique and plate choices than nails
Cons
<ul style="list-style-type: none"> • Increased chances of nonunion • Periosteal stripping • Loss of fracture haematoma • Increased blood loss • Inadequate screw purchase in osteoporotic bones • Irregular bones require plate contouring
Solutions
<ul style="list-style-type: none"> • Use of locking plates • Adequate cortices purchase on either side of fracture • Bicortical screw purchase • Use of minimally invasive techniques

4.2.4. Plates

The challenges with intramedullary nails can be partially overcome by the use of locking plates. Non-locking plates have a higher chance of implant failure because of the osteoporosis of the fixed bone and altered force biomechanics due to asymmetrical muscle paralysis and abnormal loads applied in deformed extremities. The screw purchase in polirotic bones may be inadequate, decreasing the pull-out strength and hence predisposing to construct failure. Bicortical screws should be used whenever possible. The adequate number of screws should be inserted for stable construct. This can be achieved by inserting at least four screws on either side of fracture in femur. Locked compression plating aids in achieving a better construct stability of these fractures.^{7,15}

Locking plates are like an internal fixator which provide an additional 'cortex' i.e. the plate itself for screw purchase and distribute the loads equally at all plate-screw interfaces, thus increasing the pull-out strength and improving stability.¹⁵ Chances of implant failure with locking plates are therefore much less. In a recent study multiple unilateral femoral fractures in adult polio patients were successfully fixed with locked compression plating. Nonunion was reported in only one case.¹⁵ One must supplement internal fixation with some form of bracing or plaster slab for adequate period to reduce the chance of construct failure.

Fig. 5. (A) Anteroposterior radiograph of a patient with fracture of distal femur in polirotic limb. The knee joint was already arthritic and leg deformed. Here fixation using a distal femur locking plate required unusual plate moulding to conform to the deformed bony contours. Also the screws in the distal fragment had to be carefully placed to avoid joint penetration. (B) Fracture union within 3 months.

The other problem with plates in polio is requirement of contouring the plate to conform to the altered bony shape at times.¹⁵ This may weaken the plate due to formation of stress risers and the screws may have to be passed in different directions instead of parallel (Fig. 5A and B). Use of minimally invasive techniques, preservation of periosteal blood supply, use of low contact plates and respecting soft tissues during surgery are of special mention in polio patients, considering their poor soft tissue envelope and hypovascularised bones. Small muscle bulk has the advantage of passing the plate submuscularly in a minimally invasive manner.¹⁵ Usually broad plates are used in adult patients with femoral fractures but in polio patients narrow plates may have to be used.¹⁵ Therefore plates of different sizes should be kept ready before operating such a case (Table 5).

In summary there is considerable number of challenges to treat fractures in poliotic limb. The following points should be kept in mind while internally fixing such fractures.

- Make a thorough preoperative surgical plan to overcome the problems associated with implant placement.
- Be ready for open reduction as closed reduction may not at all be possible or it may fail or it may not be feasible to place implant in an unusual position of closed reduction.
- Respect the soft tissues. Try to achieve fixation in a minimally invasive manner with minimum periosteal stripping and minimum damage to blood supply. Also a sterile aseptic technique is paramount.
- Keep all armamentarium which may be required during surgery for fixation of a particular fracture, like various small sized nails, locking plates and even an external fixator.
- Early postoperative rehabilitation is essential to achieve a good surgical outcome.

The future of fracture fixation in these patients lies in designing customized implants based on bone geometry using Computer Assisted Designing (CAD) and use of intraoperative navigation systems for perfect implant placement in a minimally invasive manner.

Conflicts of interest

The authors have none to declare.

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