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Return to Sport Following Compound Fracture and Subsequent Leg Length Discrepancy: A Case Report

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Abstract

Background and Purpose: Osteomyelitis occurs in a significant portion of open tibial fractures (up to 20%). Deformities and leg length discrepancies (LLDs) following tibial osteomyelitis are rare and difficult to treat. Numerous methods exist to correct LLD, including shortening of the longer leg by femoral subtrochanteric osteotomy and rod placement. Currently, there is sparse literature, if any, to describe prognosis of return to normal gait and return to sport with a unique combination of these comorbidities. **Case Description:** The patient in this case is a 15-year-old female with extensive history of compound fracture, tibial osteomyelitis, leg length discrepancy, and surgical femur reduction. Following surgery, the patient presented to outpatient physical therapy for strengthening and functional training. **Outcomes:** Functional improvements were observed, most significantly in decreased abnormalities of gait and a return to sport. Outcome measures including the Lower Extremity Functional Scale (LEFS) also reflected this improvement with over 50% reported improvement. **Discussion:** Patient's gait normalized, a 1 cm discrepancy remained, not anticipated to cause problems, cleared by surgeon for all activities 4 months after surgery. This case involves a unique combination of complex historical factors where prognosis was unknown. Although prior literature on prognosis of individual factors suggested positive functional results, no described cases included all major events experienced by this patient. This case is an example of the potential for excellent return to function despite a challenging course of treatment.

Keywords:

Background

Osteomyelitis occurs in a significant proportion of open tibial fractures, with greater injury severity correlating with higher rates of infection (4.5-20%). The tibia is at higher risk for infection secondary to a large bone surface with decreased soft tissue coverage, protection, and blood supply. Tibial osteomyelitis is also difficult to treat once it occurs, and demands a large amount of medical resources. To avoid failure of treatment, multiple procedures frequently are used including debridement, surgical fixation, and soft tissue and bone grafts [4].

Risk factors for osteomyelitis in children include prior surgery or presence of hardware, neurological conditions, trauma, sepsis, and systemic illness. Symptoms include abnormal drainage, pain, and swelling. Imaging may also show periosteal thickening and inflammation. In subacute and chronic osteomyelitis, the approach that is considered the treatment of choice includes surgical debridement alongside antibiotic therapy [2].

The prognosis of treating osteomyelitis is more favorable in children than in adults. However when comparing prognosis of osteomyelitis in various bones, outcomes for tibial osteomyelitis are less successful. Some literature suggests that infections of the distal tibia are harder to treat than those of the middle and proximal portions. Amputation is rarely indicated for tibial osteomyelitis, but does occur [3].

Following a chronic episode of tibial osteomyelitis, resulting bone deformities and leg length discrepancies are rare and difficult to treat. This loss of length can be a result of multiple debridements, and loss of bone to infection. In a study examining leg length discrepancy (LLD) following tibial osteomyelitis, 23 patients ages 8-16 were found to have an average discrepancy of 4 centimeters (cm). All patients were treated with a lengthening external fixator and functional results were excellent for over half of patients, while the remainder had largely good functional outcomes. Functional outcome in this study was defined by pain, independence with ambulation, lower leg deformities/contractures, loss of range of motion at the ankle, and return to work/activities of daily living (ADL's) [7].

An additional study investigating long-term functional outcomes following treatment of tibial osteomyelitis with debridement, fixation, and soft tissue flaps. Patient reports of ambulation, sport, and functional status 4 years after treatment are positive, with all patients walking and a majority walking unaided, only 2 of 12 patients reporting mild pain after walking longer distances, and all 4 patients who were involved in a sport at the time of injury had returned to their sport [4].

When a leg-length discrepancy remains following infection and bone loss, it's impact on function must be considered. Anatomic LLDs are described as a true bilateral variation in bony length of the lower extremity, from the head of the femur to the distal tibia. Among the general population, it is suggested that LLDs are relatively common, with some variation present in approximately 70% of the population, and discrepancies over 2 cm present in approximately 1/1,000 individuals. Clinically, LLD is associated with numerous musculoskeletal complaints, including back pain and sciatica, functional scoliosis, and increased rates of lower extremity stress fractures in athletes [6].

Effects of LLD on gait have been described by numerous studies. Changes in gait mechanics are seen in both short and long limbs, with short limbs exhibiting vaulting, pelvic obliquity, and increased plantarflexion, while long limbs exhibited increased knee and hip flexion, circumduction, hip abduction, and foot pronation. Utilization of a combination of these compensations are frequently described, rather than one compensation in isolation. These compensations lead to increased mechanical stress on the longer leg, and in LLDs over 3 cm compensations of gait can contribute to abnormal loading and mechanics of the spine. Research has continually sought evidence for the threshold of LLD where a functional impact is observed. Current evidence suggests that gait abnormalities may be associated with LLDs > 1 cm, with higher severity as the discrepancy increases [6].

Correcting an LLD surgically can be performed through lengthening of the short limb or shortening of the longer limb. Two primary methods exist for shortening a limb – surgically arresting bone growth at a growth plate, or resection of part of a long bone. The femur is more easily shortened than the tibia. A current method for femur shortening involves subtrochanteric osteotomy and rod

insertion with proximal nailing. Some complications associated with this procedure can include non-union, and difficulty with function of the quadriceps and hamstrings muscles. Benefits of this procedure include its stability which allows for early mobility and rehabilitation 1-2 weeks following surgery. It is also noted that recovery following lower extremity shortening is quicker than recovery following lengthening [8].

Literature describing prognosis and specifically return to sport with a combination of the above diagnoses and surgical interventions is scant. In the field of physical therapy, short term and long term goals are central to the plan of care and provide a way for patients to play an active role in shaping their care. Having knowledge of a patient's prognosis can aid in developing goals and choosing effective and specific interventions, as well as contribute to patient education. Despite the complications in return to full function following multiple comorbidities, it is important not to over-generalize or underestimate a patient's potential.

The purpose of this case report is to describe the complications and interventions involved in the rehab of a patient with a complex history including compound fracture of the distal tibia and fibula, osteomyelitis, subsequent leg length discrepancy, and surgical femur reduction; and to synthesize evidence regarding prognosis of return to sport following these historic factors.

Case Description: Patient History and Systems Review

The patient in this case is a 15-year-old Caucasian female, presenting to an outpatient orthopedic clinic with a referral for a right femur reduction. On initial evaluation, the patient was two weeks post surgery and rod placement. She arrived with her mother, walking into the clinic using two axillary crutches.

While obtaining the patient's history, it was revealed that this surgery was preceded by orthopedic trauma and several years of complications. The patient's initial injury, a left tibia and fibula fracture, took place in the summer of 2016 while playing soccer. The patient was 13 years old at the time, and described colliding with another athlete, and being on the ground with her foot bent all the way back (dorsiflexed) at the ankle. An external fixator was placed from July through October. She received 29 hyperbaric oxygen treatments to facilitate healing from late August through September of that year. She was then casted, which not long after was draining and infected. That November, the patient was diagnosed with acute osteomyelitis. Treatment in November of 2016 included bone removal and a rotational flap, which took place in two surgeries spaced 3 weeks apart. The patient came home between these surgeries with an open wound and wound vac.

In early January of 2017, the patient was declared infection free and was placed in a boot. In mid-January, she refractured and was re-diagnosed with acute osteomyelitis, learning that the previous report of being infection free was inaccurate. The patient underwent additional bone removal, with no clear indication that the infection was completely removed. She then underwent 10 debridements (of bone) throughout February, and had a muscle flap taken from her L gracilis. Following removal of all compromised bone, a Taylor Spatial Frame was put in place from March through May of 2017. The patient was again in a boot from June to July of 2017.

Following this series of debridements and bone removal, the patient had a resulting leg length discrepancy, with a longer right lower extremity. She also had significant circumferential scar tightening around her left ankle. In May of 2018, the patient underwent a 2 cm reduction of her right femur, and a left ankle scar release. This procedure was chosen because the femur is easy to resect, and also to avoid risks of performing a major surgery on the previously infected side.

Current aggravating pain factors included movements where the patient can feel a shift in her femur, and easing factors included compression from weightbearing (current status of weightbearing as tolerated), Tylenol, and ice. Screening for red flags was unremarkable. No significant medical history beyond previously described history.

The patient is a high school student, previously active in soccer, marching band, hiking, biking, and swimming. Her goals included returning to walking, getting back to marching band and soccer, and gaining independence from assistive devices with walking.

Clinical Impression #1

Following the history and systems review, the primary problem included pain and limited functional mobility. Differential diagnosis at this point included post-surgical difficulties of muscle activation (especially right quadriceps), post-surgical pain, limited left ankle mobility, myofascial restrictions, and consideration of risks for post-surgical nerve damage, refracture, and infection.

At this point we discussed prior physical therapy experiences with the patient and patient's mother. She had received therapy addressing the dorsiflexion limitation on her left ankle, including prior scar massage. The patient subjectively reported positive experiences with prior therapy. With patient permission, we also requested access to imaging following the femur reduction. This additional information helped with developing an understanding of patient buy-in to the therapeutic plan of care, and access to imaging would help paint the picture of musculoskeletal impact and involvement in the right extremity. The patient's post-operative protocol described partial weightbearing for two weeks, a gradual return to full weightbearing, and return to running/sport after 12 weeks.

After synthesizing all information, a plan was made for examination. Rational behind testing was driven by investigation of post-operative impairments. Tests selected included subjective tests: the Lower Extremity Functional Scale to examine lower extremity disability, the Patient Specific Functional Scale, and numeric pain rating scale scale. Objective measures to be taken included examining range of motion (ROM) of both lower extremities: passive hip ROM, active ROM of knee flexion, active platarflexion ROM, and active dorsiflexion ROM, all bilateral. Functional movements to be assessed included gait and straight leg raise. A volumetric assessment was also planned 10 cm above and below the knee to monitor swelling. Joint mobility testing was also planned, but due to post-surgical status only patellar mobility would be assessed. Strength would be further assessed through function with specific exercises. It was also planned to change bandages from surgical incision sites and monitor these areas for signs of infection.

This patient is a good candidate for a case report due to her complex history, rare etiology of leg length discrepancy, and unique correction of leg length on the previously non-involved extremity. The patient also presents with several risk factors throughout rehabilitation, and due to her unique prior surgeries and comorbidities, prognosis was unknown for gait, pain, and return to sport.

Examination

The examination began with self-reported assessments of the patient regarding pain and function. The patient was asked for pain levels on the Numeric Pain Rating Scale (NPRS). On a 0-10 scale, she reported 6-7/10 at worst, and 3/10 both currently and at best. The patient also completed a Lower Extremity Functional Scale (LEFS), a measure of lower extremity related disability, and scored a 23 which indicated a 71.25% functional limitation. Additionally, the Patient Specific Functional Scale (PSFS) was administered, with activity choices of marching band and soccer. The patient reported a 0/10 for function on both of these activities, indicating the lowest level of ability to perform these activities at a prior level.

Throughout the initial examination, the patient was in long-sitting on the mat table.The incision site was examined and dressings changed. Two small incisions existed on the lateral upper right thigh, covered with medium size adhesive bandages. Both incisions were draining a clear exudate and the skin around the incision did not appear red or inflamed. A volumetric assessment was performed on both lower extremities, to monitor swelling of the right leg. Circumferential measurements were taken 10 cm above and below each knee, with results as follows: 10 cm above knee: right 49 cm, left 46 cm; 10 cm below knee: right 37 cm, left 36 cm. This indicated a slight increase in volume on the right leg, likely due to post-surgical swelling.

Active ROM was performed and measured with goniometry to understand current ROM restrictions and establish baseline values prior to therapeutic intervention. Measurements were taken with the patient supine on the mat table with a pillow supporting the right lower extremity. Active ROM

of bilateral knees and ankles were as follows: right: knee flexion 85*, plantarflexion 56*, dorsiflexion 10*; left: knee flexion 132*, plantarflexion 28*, dorsiflexion 6*. Passive ROM of each hip into flexion was within functional limits. Assessments of ROM revealed relative restrictions in right knee flexion, and left ankle dorsiflexion and plantarflexion. Joint mobility was assessed at both patellas to contribute to information regarding knee ROM. Inferior and superior glides of the patella were relatively limited on the right.

Assessment of functional movements and performance of strengthening exercises was completed following other assessments. The patient ambulated approximately 40 feet in the back hallway of the clinic with crutches and internal rotation of her left foot was observed. While supine on the mat table, the patient was instructed in a straight leg raise (SLR), measured with an inclinometer. She was able to raise her left leg to 60* without pain, and was able to raise her right leg to 60*, with extensor lag and pain. Manual muscle testing was not completed at this point due to the patient's pain sensitivity and clinical judgement used to avoid extensive position changes in an early post-surgical state. The patient was able to perform a simple exercise program including: quad sets, heel slides, long arc quad, and clamshells(on right); sidelying hip abduction (left leg); and SLR and ankle pumps.

A functional movement screen (FMS) and Lower Quarter Y Balance Test (YBT-LQ) were performed approximately four months after initial evaluation. The patient scored below standard scores in many of the lower extremity components of the FMS, including deep squat, hurdle step, inline lunge, and also in the trunk stability pushup. On the YBT-LQ, she received scores below standard scoring, which for both the YBT-LQ and FMS was judged in comparison to other high school soccer players. Move2Perform software was used to analyze these test results and help predict risk for injury with sport. The patient's deficit category was classified as a moderate deficit.

Clinical Impression #2

Following the examination, initial impressions of post-surgical decreases in strength were confirmed and more specifically identified to include bilateral hip abductors, and bilateral quadriceps (especially on the right). Regarding limited left ankle mobility and right knee flexion limitations, these suspicions were also confirmed through testing. The initial impressions of pain and limited functional mobility were confirmed by self-reported measures, and comprised the working diagnosis. Despite unknown prognosis for her case, goals were created for return to sport.

After evaluating examination results and clinical impressions, the plan to continue with intervention proceeded. The presence of no red flags, along with the patient's ability to participate in strengthening and mobility exercises supported the appropriateness of physical therapy in this case. The patient continues to be a good subject for a case study investigating prognosis with her complex history. Due to the extent of soft tissue involvement, we discussed myofascial therapy at this point as an avenue to further explore to help address range and function.

The plan for clinical intervention included strengthening, specifically bilateral quadriceps and hip abductors, bilateral gluteal muscles, stretching of the left ankle to improve dorsiflexion mobility, continued monitoring of right thigh incision sites, left ankle scar massage, prone knee bends (on right) with overpressure to improve flexion ROM, and ambulation with faded support.

A plan was also established at this time for assessment of outcomes. These tests included the Global Ratings of Change scale (GROC), as well as continued re-testing with the LEFS, PSFS, and NPRS. Physical assessment would also be performed through functional performance of increasing load with strengthening exercises, visual gait analysis, and goniometric measurement of right knee and left ankle ROM. Formal re-evaluation was planned for every 30 days.

As the patient became more independent with ambulation, moving to use of one crutch and then no ambulatory aids, major gait abnormalities became apparent. In addition to in-toeing on the left, she exhibited a pronounced Trendelenburg gait pattern, and circumduction on the right. Throughout the progression of strengthening, various muscle groups were targeted to address deficits contributing to these gait abnormalities. Muscle groups of high importance included gluteal muscles/hip extensors, and

hip abductors. As various strengthening strategies were implemented, it was unclear what optimal gait would look like under the patient's unique circumstances.

Interventions

Treatment focused on lower extremity strengthening and stabilization exercises, and manual therapy to improve joint mobility. Strengthening initially focused on right quadriceps activation. Exercises progressed from quad sets and inability to perform a straight leg raise without pain and extensor lag to full SLR and squats. Russian electric stimulation was included in treatment to assist with quad activation. Additionally, strengthening of gluteal muscles and hip abductors was emphasized to help correct abnormalities of gait. Manual therapy included scar massage of the left ankle, prone knee bend assisted stretching to increase right knee flexion ROM, and prone hip extension mobilizations.

Gait was addressed through hip abductor strengthening and stability to reduce Trendelenburg, and manual therapy and stretching to hip extension ROM for improved hip extension during gait. Additional impacts on gait were contributed through stretching and mobilizations to address left ankle mobility, and utilization of custom orthotics.

As the patient progressed toward normalized gait and demonstrated improving function, interventions were incorporated to facilitate patient goals of returning to soccer and marching band. Prognostically, prior literature on return to sport could not be generalized to the patient due to the high-level nature of sports she planned to return to. A return to run program was initiated, and higher-level athletic exercises and soccer drills were implemented.

Outcomes

Self-reported assessments taken at initial evaluation were reassessed at each reevaluation. In mid-September, the patient's LEFS score had improved to 65/80, indicating a percentage limitation of 18.75%. This was a marked improvement from the initial percentage limitation of 71.25%. Also on this date, PSFS values for soccer and marching band were reported as 6/10 and 8/10 respectively. This exceeds the minimal clinically important difference for improvement in the PSFS. The patient also reported a +6 on the GROC, indicating she perceived her status was "a great deal better" than prior to initiating therapy (maximum score = +7).

In early October 2018, the patient returned to orthopedic surgeon for follow up. Multiple images were taken, and healing of her right femur continues to be good. At this time it was also concluded that she has a remaining 1 cm discrepancy, with the right leg longer. This difference was not expected by her physician to lead to long-term issues. The patient was cleared for all activities and no follow up was planned, as the patient now only needs to return if issues arise.

In early December 2018, the Functional Movement Screen was performed for a second time, with the patient achieving a minimum of passing scores in all categories (compared to prior results with many categories below standard scores).

With regards to return to sport, the patient's first soccer game also took place in early December. She reported a positive experience. The patient was also able to finish the marching band season, and is now starting pep band.

The patient has received continued therapy to address goals as she returned to running, soccer, and marching band. She has continued to improve and has achieved a full return to activities without pain. Additionally, custom orthotics were fit which further decreased her remaining discrepancy and improved function. Discharge is anticipated in late December 2018.

Discussion

The purpose of this case report was to summarize the literature regarding prognosis with a variety of orthopedic impairments (compound fracture, tibial osteomyelitis, leg length discrepancy, and surgical femur reduction) and compare this literature with functional outcomes in a patient case, as well as to report the examinations, interventions, and complications involved in this patient's treatment.

In cases of tibial fractures, osteomyelitis is relatively high compared to rates in other bones. Tibial osteomyelitis occurs in approximately 4.5-20% of fractures [4]. Rarely, tibial osteomyelitis results in deformities and leg length discrepancies (LLD). Treatment of such deformities with external fixation has been reported in literature to laregly lead to excellent functional results [7].

LLDs may be surgically corrected with numerous methods. A large proportion of literature describes limb-lengthening procedures, however limb-shortening is also an option. In studies examining functional outcomes following surgical femur reduction to correct for LLD, positive functional outcomes are also described [8].

This study demonstrates the full return to sport achieved following multiple orthopedic insults that previously had no published comprehensive prognostic indications. It would not be reasonable to assume that a positive functional prognosis can be generalized to a person with a combination of these comorbidities. The length of rehabilitation in this case, 7 months, is significant. Considering the limited amount of cases in which to compare recovery time, questions are raised regarding the interventions used and if changes could have shortened time from initial evaluation to discharge. In literature describing femur shortening procedures, reported complications include function of the quadriceps post-surgically [8].

In this case, the patient experienced complications throughout physical therapy treatment of lower extremity weakness, abnormalities of gait, pain, and decreased functional mobility. She ultimately achieved her goal of full return to soccer. Outcomes may have changed had her sport of choice been different. Additional research could examine the impact of multiple complications following fracture on return to ballet, gymnastics, or other activities involving precise execution of detailed movements.

The post-operative protocol following the patient's femur reduction described a return to running/sport at 12 weeks post operatively. This differed from the actual full return to sport at approximately 6.5 months postoperatively. Additional research could investigate discrepancies between post-operative protocols of various orthopedic surgeries and clinical results for return to activities.

When treating a patient with an unknown prognosis, it can be more difficult to set realistic and achievable goals, and thus to develop a plan of care. Developing the plan of care with input from the patient contributes to a good prognosis and stronger therapeutic alliance. Future research could investigate other situations of multiple orthopedic insults where little prognostic evidence exists and examine the impact of this knowledge gap on functional outcomes and the therapeutic alliance.

Due to the numerous complications in this patient's recovery from initial fracture in July of 2016 to discharge from physical therapy in December of 2018, multiple health disciplines were involved over the span of her treatment. Nursing, wound care specialists, orthopedic surgeons, and physical therapists all contributed to her return to function. This highlights the importance of a multidisciplinary approach in managing all apsects of care when multiple comorbidities are present.

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