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Laura K. Parry
Utah State University

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**FACTORS AFFECTING THE OUTCOMES IN BILATERAL TOTAL KNEE
ARTHROPLASTY: A CASE REPORT**

By:

Laura Parry ATC,LAT

A Plan B Project submitted in partial fulfillment of the requirements for the degree

Of

MASTER OF SCIENCE

In

HEALTH AND HUMAN MOVEMENT

Approved:

Dr. Dennis Dolny
Major Professor

Dr. Eadric Bressel
Committee Member

Bryan King M.D.
Committee Member

Lori Olsen PT
Committee Member

FACTORS EFFECTING THE OUTCOMES IN BILATERAL TOTAL KNEE ARTHROPLASTY: A CASE REPORT

INTRODUCTION

Osteoarthritis (OA) is a debilitating condition that affects a large population around the world. In the United States, OA is one of the leading causes of functional disability, and its occurrence is steadily rising (Mizner, Petterson, & Snyder-Mackler, 2005). Currently OA affects 13.9% of adults 25 years and older, as well as, 33.6% adults age 65 and older. The most commonly affect areas include the knees, hips, hands and spine (CDC, 2011).

Osteoarthritis is classically described as a gradual degenerative disease that is characterized by decline of structural integrity of the articular cartilage and underlying bone of a joint. The breakdown of these tissues leads to the commonly seen symptoms of joint pain, stiffness, and decline in functional abilities (CDC, 2011).

OA does not necessarily result from a single issue, but usually occurs as a result of multiple factors that cause changes in the structure of the joint. Differentiation between traumatic OA and non-traumatic OA is difficult without prior knowledge of injury or signs of previous surgeries or trauma. An individual who has sustained an injury that affects the cartilage and subchondral bone may be at an increased risk for developing early signs of OA (Sward, et.al., 2009).

There is no cure for OA, but systematic treatment of symptoms assists in decreasing pain and improving function. Since there may be no known cause of OA, treatment addresses many areas. Common conservative treatments include physical therapy, weight control, and medications (CDC, 2011). When conservative treatment of OA is not enough to relieve symptoms, joint replacement is the next course of action (Mizner et.al., 2005). By 2030, it is

estimated that about 500,000 total knee replacement surgeries will occur annually in the United States (Mizner, et. al., 2005).

Total knee arthroplasty (TKA) is a common treatment of OA in the knee. A prosthetic device replaces the knee joint. The goal of TKA is to improve functional outcomes of the patient (Barbay, 2009). While the quality of the patient's life generally improves following joint replacement therapy, there are surgical risks (see Appendix C) (Mizner, et.al., 2005, Noble, et.al., 2009, Akhtar, & Houlihan-Burne, 2010).

In cases where severe disability is present in both knees a simultaneous bilateral total knee replacement (SBTKR) is recommended. SBTKR surgeries can be highly successful, but it is important to note the risks and potential complications that a patient might experience (Noble, et.al., 2009). The risks that are present in unilateral TKA are also present in SBTKR. However, greater risk and slower recovery time may persist in SBTKR due to the simultaneous replacement of both joints (Mizner, et.al., 2005, Noble, et.al., 2009, Akhtar, & Houlihan-Burne, 2010). Post-operative pain is a general concern for most patients and for physicians.

Recently a technique called continuous femoral nerve blocks or infusions (CFI) have been growing in popularity for patients undergoing TKA. CFIs involve a catheter being placed near the proximal portion of the femoral nerve through which anesthetic bathes the area around the nerve. The anesthetic and the catheter do not invade the nervous tissue, instead the anesthetic is applied to the area surrounding the nerve (Chelly, et.al., 2001; Salinas, et.al., 2006). Some studies have shown that CFI has been helpful in the early initiation of rehabilitation and has decreased the length of hospital stay. CFI has allowed for better pain control following surgery with a decrease in side effects compared to other techniques. For example in a TKA a continuous passive motion machine was better tolerated, improving functional recovery

compared to the use of other non-regional anesthesia methods(Chelly, et.al., 2001; Salinas, et.al., 2006).

Compared to other anesthesia methods, general anesthesia and oral or intravenous pain medication, there is some question as to whether CFI delays the ability to activate the quadriceps muscles following TKA. This question is based largely on anecdotal evidence. The femoral nerve block temporarily affects the nerve activation and if the anesthesia does not wear off within a reasonable amount of time, then the firing of the femoral nerve and its branches may have been delayed. If quadriceps activation is delayed due to the anesthesia there is question whether functional outcomes will be affected. There is a high correlation to functional performance and the activation of the quadriceps (Greene, et.al., 2008; Mizner, et.al., 2005). By improving the strength of the quadriceps, the outcomes of a TKA also improve (Mizner, et.al., 2005). Since quadriceps weakness persists following TKA, it is imperative that the rehabilitation program focus on increasing quadriceps strength in order to improve function of the patient (Greene, et.al., 2008; Mizner, et.al., 2005).

The effect of CFI on quadriceps muscle activation and reactivation is not well understood. There is anecdotal evidence that the use of CFI in TKA and ACL patients may delay reactivation of the quadriceps muscle, which may in turn delay initial progress of rehabilitation and return to functional activity. The purpose of this case study was to determine the effects of femoral nerve block use during total knee arthroplasty on the return of quadriceps activation and functional outcomes in a single patient. This case study focused on an individual case consisting of simultaneous bilateral knee replacement. The individual received a femoral nerve block in one knee and traditional anesthesia in the other. We considered the improvement in functional outcomes following surgery. It was expected that the femoral nerve block will

delay the activation of the quadriceps muscle and the return of functional measures. However, the femoral nerve block will modulate pain more successfully compared to the standard pain control procedures. This case study will also address the effect of femoral nerve blocks on quadriceps, particularly Vastus Medialis Oblique, reactivation following TKA. If so, for how long is quadriceps activation delayed. Is return of balance and proprioceptive control delayed following use of a femoral nerve block during TKA.

METHODS

This case study observed a patient who received a simultaneous bilateral total knee arthroplasty (SBTKA). A single case research design was implemented. Observation of the participant lasted from one week prior to surgery to 12 months following surgery (see Appendix A).

Participant

One male participant, 53 years of age, scheduled for a simultaneous bilateral total knee arthroplasty, volunteered to participate in this study. Prior to surgery the participant's height was 165cm and weight was 96.16kg. The patient was examined by an orthopedic surgeon who deemed the surgery necessary (see Appendix A). The anesthesiologist assigned to this patient's case gave the right leg a continuous femoral nerve block; the left leg received local anesthetic. The subject also received an epidural injection, per common anesthesia protocols for total knee arthroplasty. See Appendix A for full physician evaluation and operation report. Subject and surgeon agreed to the procedures listed below, prior to surgery.

Procedures

Initial baseline testing occurred approximately one week prior to surgery. The patient was allowed to participate in physical activity as tolerated prior to surgery. This may have

included use of the underwater treadmill, low-impact cardiorespiratory exercise, and resistance exercises. Exercise prior to surgery was not regulated by the study.

The participant underwent simultaneous bilateral total knee replacement on November 11, 2011 (see Appendix A for description of procedure). Following surgery, a rehabilitation program began with a physical therapist per physician’s instruction and per surgery protocol. Weekly measures and physical therapy measures were taken to assess progress made by the participant. Major functional tests were assessed at 1, 2, 3, 4, 5, 6, 9 and 12 months following surgery (see Table 1). The participant’s rehabilitation was followed until functional goals were met and the individual was released from physical therapy by the overseeing physician.

Table 1. Matches the testing session number with a description of the time point during the observation period.

Time Point In Recovery	BL* (1) One Month Post Op (2) Two Months Post Op (3) Three Months Post Op (4) Four Months Post Op (5) Five Months Post Op (6) Six Months Post Op (7) Nine Months Post Op (8) One Year Post Op (9)
EMG and KOOS Survey	BL* (1) 3d Post-Op (2) 6d Post-Op (3) 9d Post-Op (4) 2wks Post-Op (5) 1mo Post-Op (6) 2mo Post-Op

(7)
3mo Post-Op
(8)
4mo Post-Op
(9)
5mo Post-Op
(10)
6mo Post-Op
(11)
9mo Post-Op
(12)
12mo Post-Op
(13)

*BL=Baseline

**Post-Op=Post operation

Equipment

Equipment used to assess the participant’s physiological and functional changes included:

Knee injury and Osteoarthritis Outcome Survey (KOOS), a Baseline goniometer for ROM, a Stopline stop watch for the Timed Up-and Go test, the Delsys EMG system, Boston, Massachusetts for isometric quadriceps activation, Neurocoms® Clinical Research System, Clackamas, Oregon, to test functional variables.

Evaluation Procedures

The tests consisted of bilateral knee range of motion (ROM) both active range of motion (AROM), and passive range of motion (PROM). ROM was measured using a goniometer and standard measurement techniques. Quadriceps activation utilizing the Delsys EMG system while performing an isometric contraction was a standard outcome measure used in this study. Functional testing included the Time Up-and-Go test and other balance and stability tests. Motor control, limits to stability, and forward lunge were assessed using the Neurocom® Clinical Research System Smart Balance Master and Long Force Plate. This system uses a force plate, which can detect changes in balance and force distribution.

Delsys EMG System

Each testing session for the EMG required set up and calibration of the Delsys EMG System. The participant was positioned in a supine sitting position. The tester cleaned the skin

over the Vastus Medialis Oblique Muscle with alcohol and then placed the channel one electrode in-line with the direction of muscle fibers. The channel two electrode was placed on the cleaned skin above the muscle belly of the hamstring muscle. The root mean squared value (RMS) depicted the mean activation of the quadriceps muscle over three trials. The subject isometrically contracted the quadriceps for ten seconds while the Delsys system recorded and muscle activity. A mean of the three recorded RMS values was calculated and used for analysis.

NeuroCom® Clinical Research System SMART Balance Master and Long Force Plate

The participant completed a battery of tests using the NeuroCom ®System at monthly intervals following surgery. The tests included: Sensory Organization Test (SOT), Motor Control Test (MCT) and the Adaptation Test (ADT). The SOT assessed the participant's use of sensory systems that contribute to postural control. These systems include: somatosensory, visual and vestibular. The MCT was used to determine the ability of the motor system to react to a unexpected disturbance in the force plate. The ADT evaluated the participant's ability to react to changes in support surface (NeuroCom, 2011). The participant was harnessed and aligned on the force plate per instructions provided by the NeuroCom program. The participant was asked to stand in the Balance Master® System in a relaxed stance, and was cued how to react to the different tests per instructions on the screen.

Following the Balance Master ® tests, the participant performed a battery of test on the Neurocom ®Long Force Plate. These tests included: Limits of Stability (LOS) and, Forward Lunge (FL). The LOS tested the limit the participant was able to change their center of gravity. The test measures the distance in which they moved their mass without falling over. The FL assessed the participant's movement through a forward lunge. The participant was asked to step forward and lunge down as fast, and as comfortable as possible. The force plate recorded

movement patterns (NeuroCom, 2012). The participant was again aligned according to instructions provided by the NeuroCom program.

KOOS Survey

Common assessments that were used in physical therapy to track healing and progress of the patient include girth measurement and the Knee Injury and Osteoarthritis Outcome Score (KOOS) (see Appendix B). The KOOS Survey was broken down into a five point Likert scale. The participant rated each question on a scale from 0 to 4. The scores were then normalized and calculated for each question answer. 100 indicated no symptoms and 0 indicated extreme symptoms. The survey was broken down into five sections: Symptoms, Pain, Activities of Daily Living, Sport/Recreation, and Quality of Life (KOOS User's Guide, 2012).

Other important assessments such as pain assessment using the VAS Pain Scale, strength gains, progression through exercise difficulty and subjective measures including exercise tolerance that are made physical therapy to monitor the outcome of the patient were also included in this study (See Appendix B).

Throughout the rehabilitation process, re-testing of appropriate measures such as ROM and pain occurred on a regular basis per physical therapist observation. Assessment and progress notes by the physical therapist and surgeon were included in this study. These assessments are based around goals and bench marks put in place by the physical therapist and physician. The participant followed a specific protocol for rehabilitation as prescribed by the surgeon. ROM and girth measurement occurred on a weekly basis until the measurements returned to near normal levels, while tests involving the Neurocom system, Delsys EMG and the Biodex occurred on specific testing dates throughout the remainder of the 12month observation period.

RESULTS

Results revealed little difference between right and left leg. This study merely compared right to left sides in all tests and pre-surgery with post-surgery test scores.

The EMG data for both vastus medialis oblique (VMO) muscles displayed a very similar pattern (see Figure 2.). The root mean squared value (RMS) shows the mean activation of the VMO muscle over three trials. The left leg appears to drop below the right leg around the fourth testing session which is about two weeks post-surgery, remains lower than the right leg until around the sixth testing session (about one month following surgery) and then proceeds to return to a similar level as the right leg by two months post surgery.

Figure 2. EMG for the Vastus Medialis Oblique muscle measured in RMS. Testing sessions are listed as 1-13 and correspond to testing dates (see Table 2.).

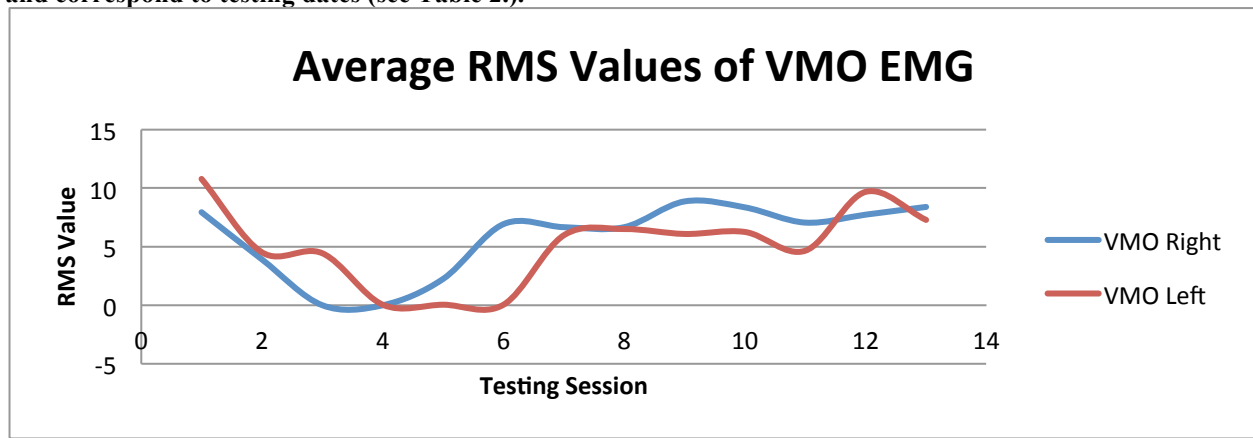


Table 2. Mean RMS Values of VMO for Right and Left Leg

Mean RMS Value	Pre-Test (1)	3d Post-Op (2)	6d Post-Op (3)	9d Post-Op (4)	2wks Post-Op (5)	1mo Post-Op (6)	2mo Post-Op (7)	3mo Post-Op (8)	4mo Post-Op (9)	5mo Post-Op (10)	6mo Post-Op (11)	9mo Post-Op (12)	12mo Post-Op (13)
Right	7.93	3.91	*2.25	*2.25	2.25	6.93	6.67	6.67	8.87	8.36	7.06	7.74	8.40
Left	10.8	4.52	4.44	0.046	0.046	0.046	5.98	6.51	6.09	6.26	4.66	9.69	7.29

Table 2. RMS values for the EMG testing of the VMO muscle for both right and left legs. “E” denotes the exponent value.

*Original data was replaced with expected values due to outliers in the original data.

*Original values were multiplied by 100000 to produce more normal numbers for easier data analysis

The KOOS Survey demonstrated a steady improvement in all categories. Initially the scores decreased following surgery, as expected. Pain and disability increased immediately

following surgery, and then decreased as recovery from the procedure progressed and physical therapy was completed (see Figure 3 and Table 3).

Figure 3. Knee Injury and Osteoarthritis Outcome Score. 100 indicated no symptoms and a score of 0 indicated extreme symptoms.

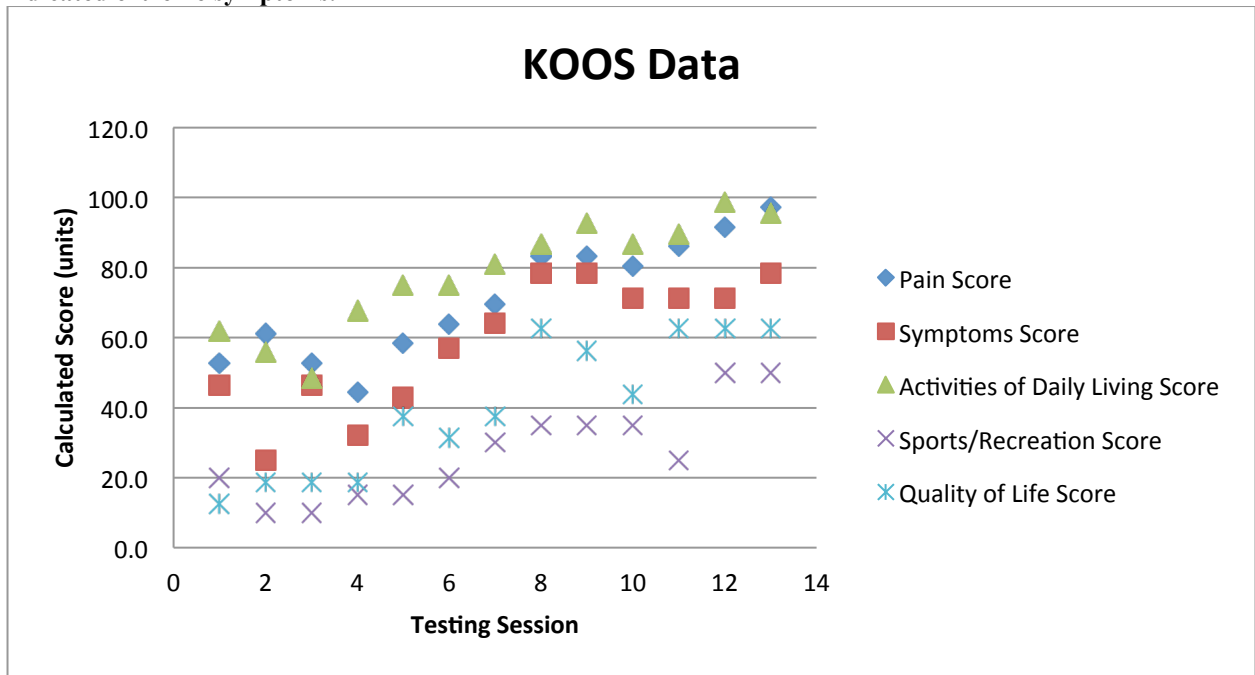


Table 3. Knee Injury and Osteoarthritis Outcome Scores. Shows the participants subjective evaluation of knee health throughout the observation period.

KOOS Data Table					
Testing Session	Pain	Symptoms	ADL	Sport/Rec	QOL
Pre-Test (1)	52.8	46.4	61.8	20	12.5
2	61.1	25.0	55.9	10	18.75
3	52.8	46.4	48.5	10	18.75
4	44.4	32.1	67.6	15	18.75
5	58.3	42.9	75.0	15	37.5
6	63.9	57.1	75.0	20	31.25
7	69.4	64.3	80.9	30	37.5
8	83.3	78.6	86.8	35	62.5
9	83.3	78.6	92.6	35	56.25
10	80.6	71.4	86.8	35	43.75
11	86.1	71.4	89.7	25	62.5
12	91.7	71.4	98.5	50	62.5
13	97.2	78.6	95.6	50	62.5

Table 4 illustrates the outcome measures evaluated during each physical therapy session.

Girth, ROM, Strength, and Timed-Up-and-Go test all showed a predictable pattern. Girth

increased due to swelling following surgery but returned to near normal by post-op month four. ROM and quadriceps strength decreased following surgery and then returned to within normal limits by three months post-op. The right leg exhibited an extension lag until the one month post-op mark. The left leg exhibited no extension lag. The Timed-Up-and-Go test showed an increase in time to complete test initially following surgery. The participant required use of crutches (partial weight bearing) due to a tibial fracture that occurred during the surgery. The participant used the crutches until one month post-surgery. The participant was unable to return to baseline speed throughout the 12 month observation period.

Table 4. Physical Therapy Outcome Measure

	Pre-Test	3d Post-Op (2)	6d Post-Op (3)	9d Post-Op (4)	2wks Post-Op (5)	1mo Post-Op (6)	2mo Post-Op (7)	3mo Post-Op (8)	4mo Post-Op (9)	5mo Post-Op (10)	6mo Post-Op (11)	9mo Post-Op (12)	12mo Post-Op (13)
Girth (cm)													
Right (mid patella)	40.0	44.4	41.3	41.9	41.9	41.3	40.6	41.9	41.9	WNL	WNL	WNL	WNL
Left (mid patella)	40.0	43.2	41.3	40.6	40.6	41.3	41.3	41.9	42.5	WNL	WNL	WNL	WNL
Right (3in Sup. Patella)	45.7	48.9	47.6	46.3	45.7	45.7	44.4	45.7	46.9	WNL	WNL	WNL	WNL
Left (3in Sup. Patella)	49.5	48.3	46.9	46.9	45.7	45.7	45.7	45.7	46.9	WNL	WNL	WNL	WNL
ROM (degrees of Flexion)										WNL	WNL	WNL	WNL
Right	136	80	90	117	120	127	130	WNL	WNL	WNL	WNL	WNL	WNL
Left	140	88	89	122	123	127	130	WNL	WNL	WNL	WNL	WNL	WNL
Strength (MMT)													
Right	5/5	Unable to SLR	Good SLR w/ ext. lag 10degrees	Good SLR w/ ext. lag 5degrees	Good SLR w/ ext. lag 5degrees	Good SLR	Good SLR	WNL	WNL	WNL	WNL	WNL	WNL

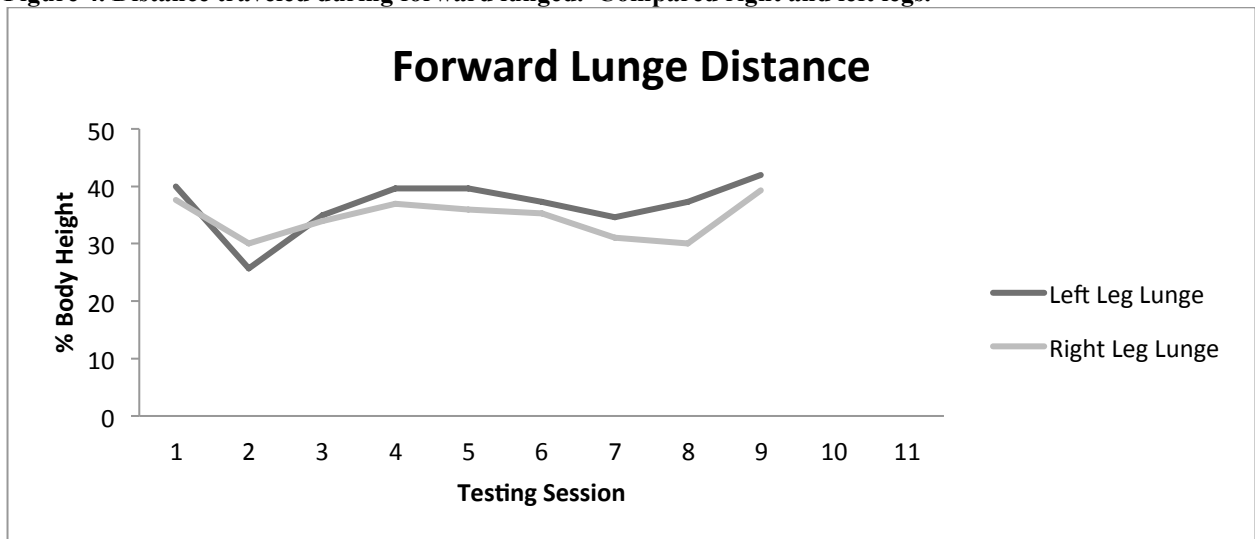
Left	5/5	Able to SLR	Good SLR w/o ext. lag	Good SLR w/o ext. lag	Good SLR w/o ext. lag	Good SLR	Good SLR	WNL	WNL	WNL	WNL	WNL	WNL
TUG (seconds)	4.1 FWB	35.1 PWB	15.6 PWB	10.7 PWB	10.6 PWB	8.6 FWB	7.89 FWB	6.64 FWB	6.0 FWB	6.3 FWB	6.4 FWB	5.4 FWB	5.2 FWB

Table 4. Displays participants outcomes during physical therapy.

SLR=Straight Leg Raise
WNL=Within Normal Limits
PWB=Partial Weight Bearing
FWB=Full Weight Bearing

The data for the Forward Lunge (FL) shows similar patterns for right and left legs (see Figure 4). Visually the right leg seems to have some deficit when compared to the left leg in all measurements, but no drastically significant difference is able to be determine based on the data provided. The Impact Index shows the greatest difference between right and left legs. The left leg exhibits a much greater impact index compared to the right leg following the third testing session.

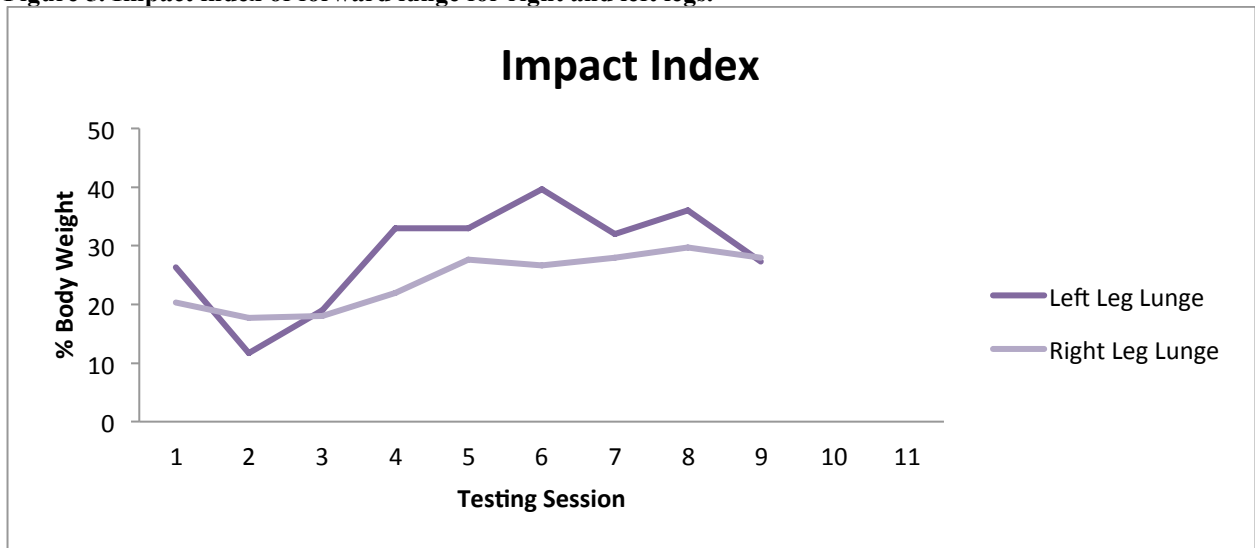
Figure 4. Distance traveled during forward lunged. Compared right and left legs.



*Number 1 testing session represents the baseline score

**Right Leg received the nerve block

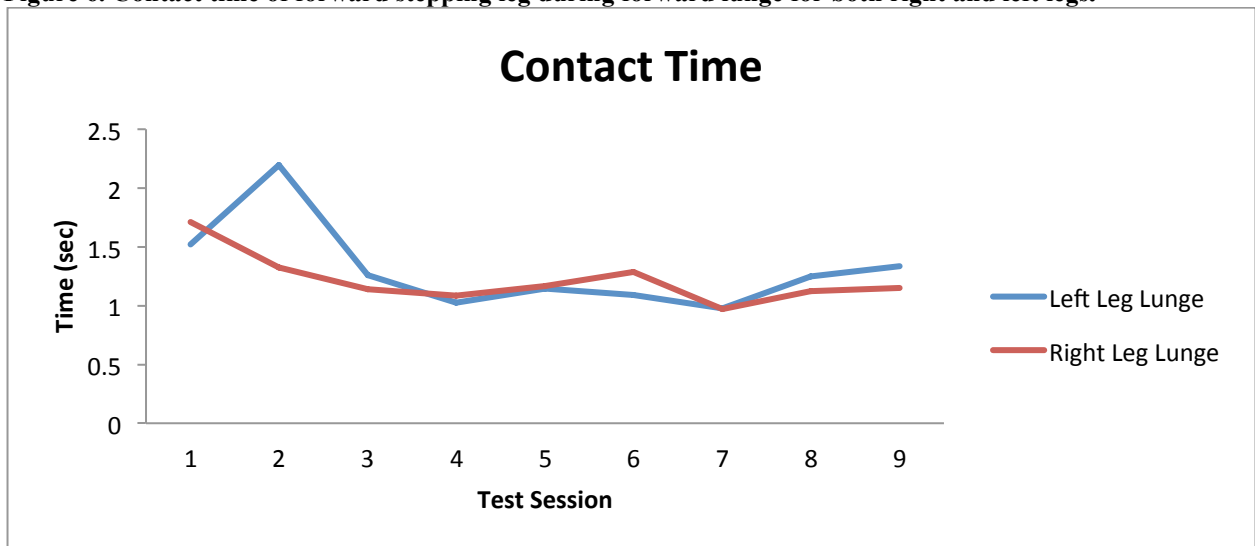
Figure 5. Impact index of forward lunge for right and left legs.



*Number 1 testing session represents the baseline score

**Right Leg received the nerve block

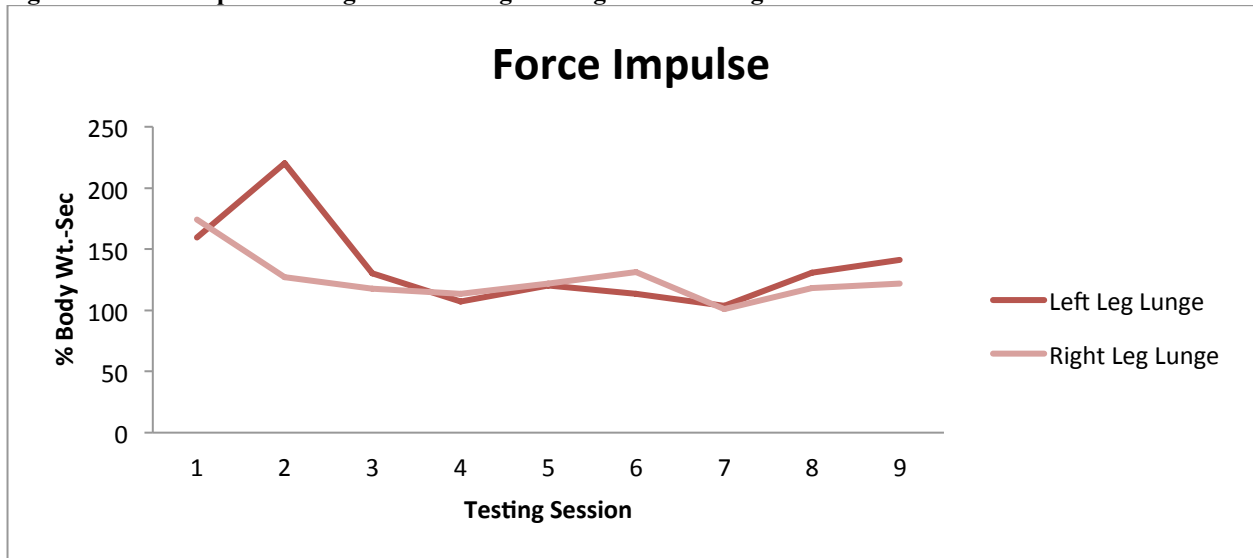
Figure 6. Contact time of forward stepping leg during forward lunge for both right and left legs.



*Number 1 testing session represents the baseline score

**Right Leg received the nerve block

Figure 7. Force Impulse for right and left legs during forward lunge.

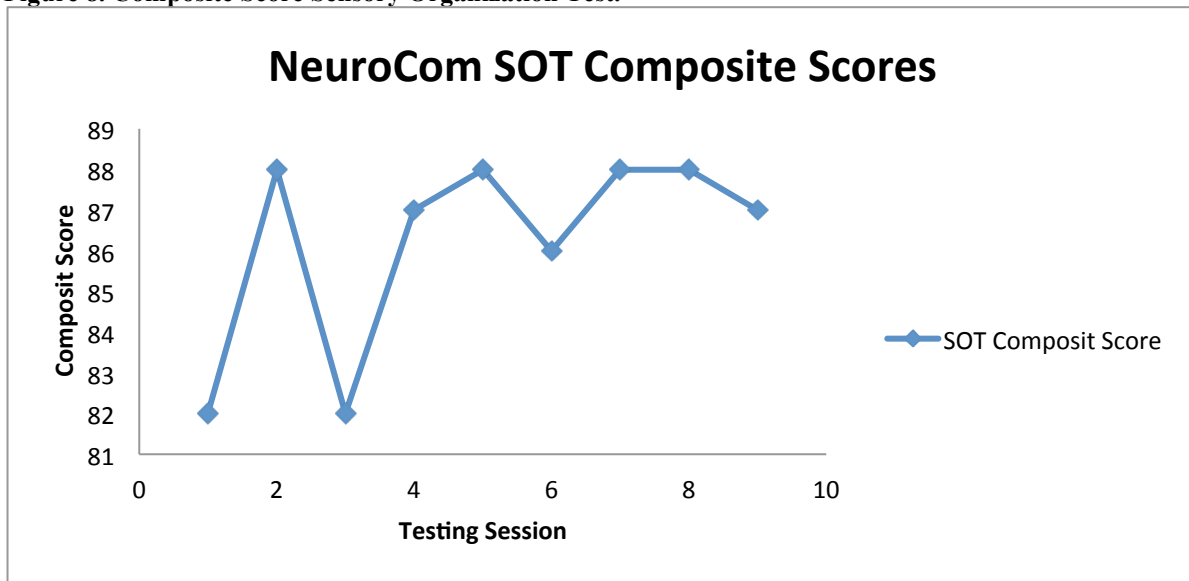


*Number 1 testing session represents the baseline score

**Right Leg received the nerve block

The NeuroCom Sensory Organization Test assessed the participant's ability to utilize three sensory systems to maintain postural control. The scoring of six conditions produced a composite score (see Figure 8). Initially the participant exhibited a low composite score during the baseline test. The participant's score improved for the second test which may have been related to test familiarity. The score demonstrated an inconsistent improvement over the 12 month observation period. The final score was greatly improved from baseline.

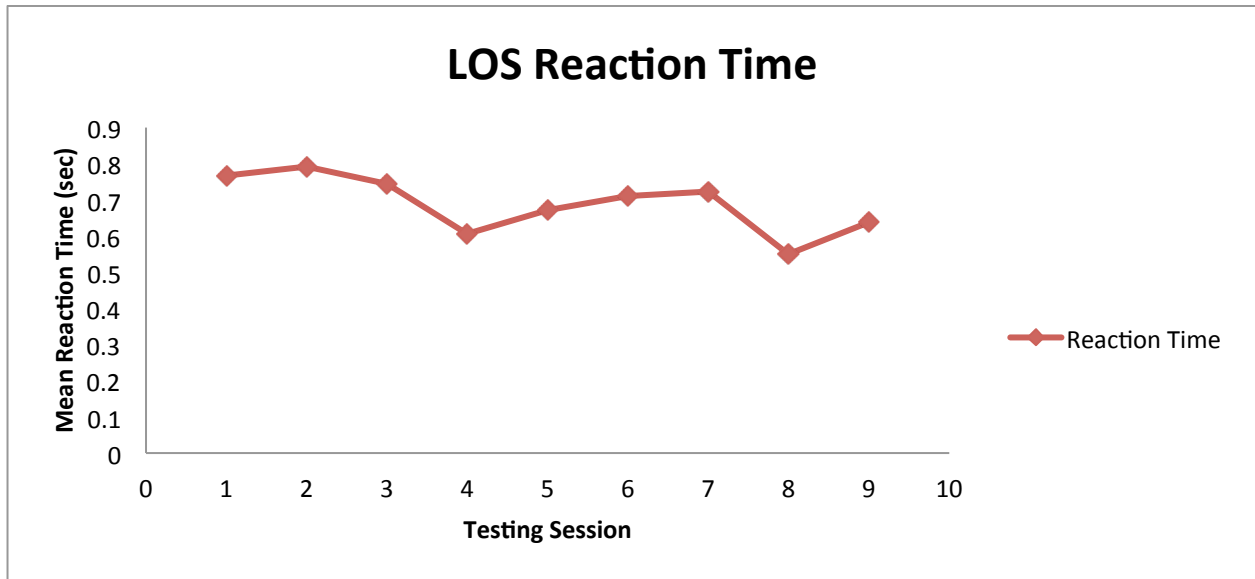
Figure 8. Composite Score Sensory Organization Test.



*Number 1 testing session represents the baseline score

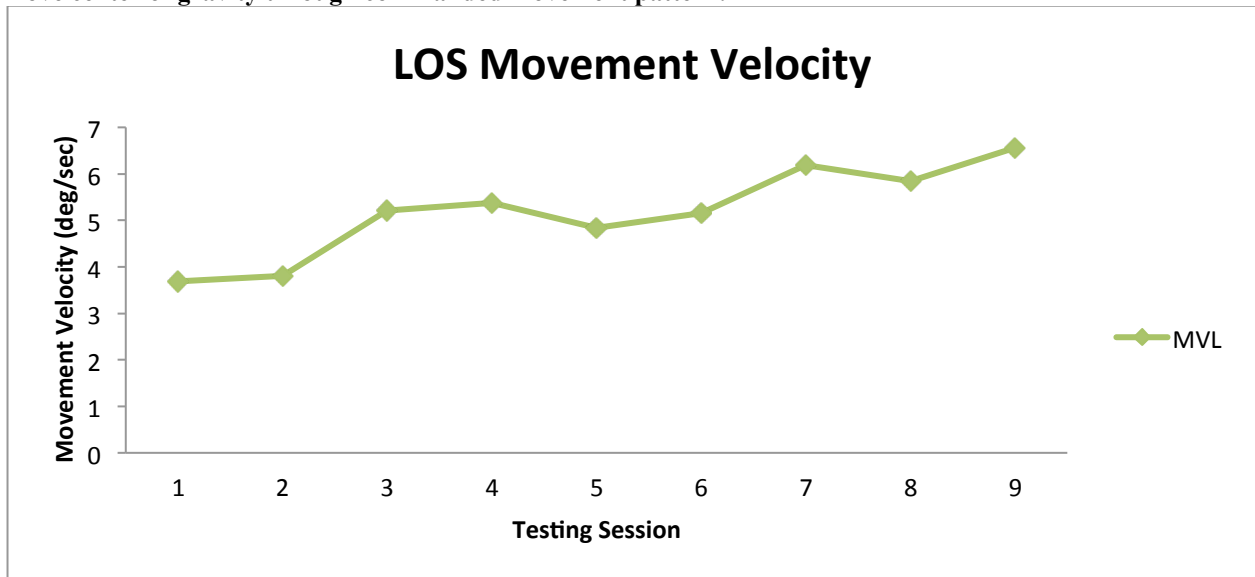
The data from the NeuroCom Limits of Stability (LOS) Test remained very steady overtime. LOS test assessed the ability of the participant to move center of gravity from initial start position to a target position. The LOS test Reaction time decreased post-surgery until about month 3, then steadily improved until the 6 month mark. It declined for the 9 month test and then began to improve again for the final observation (see Figure 9). Movement velocity represented by degrees of movement per second showed steady improvement over time. From baseline to final observation, the participant improved by approximately 3deg/sec (see Figure 10). Endpoint excursion remained very steady over the observation period (see Figure 11). Maximum excursion showed a steady improvement from baseline to final test. Between month four and month 12 the maximum excursion decreased and then climbed again to produce a personal best (see Figure 12). Directional control showed a very unsteady decline in performance over observation period (see Figure 13).

Figure 9. Limits of Stability Test. Recorded reaction time between movement command and the participant's initiation of movement.



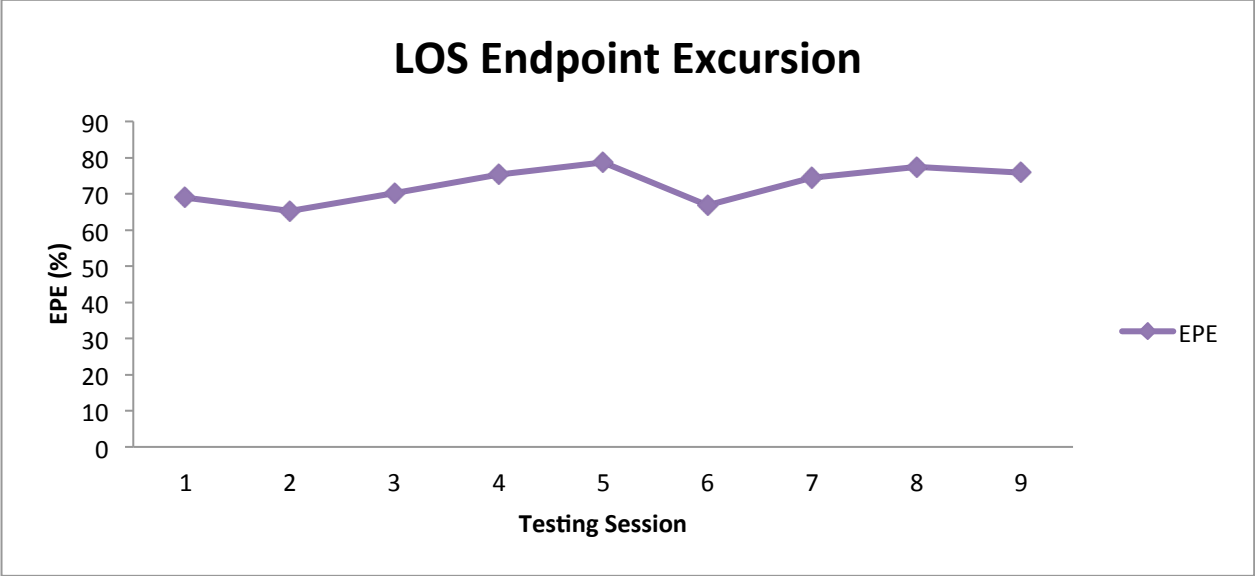
*Number 1 testing session represents the baseline score

Figure 10. Limits of Stability test. Recorded average speed in degrees per second the participant was able to move center of gravity through commanded movement pattern.



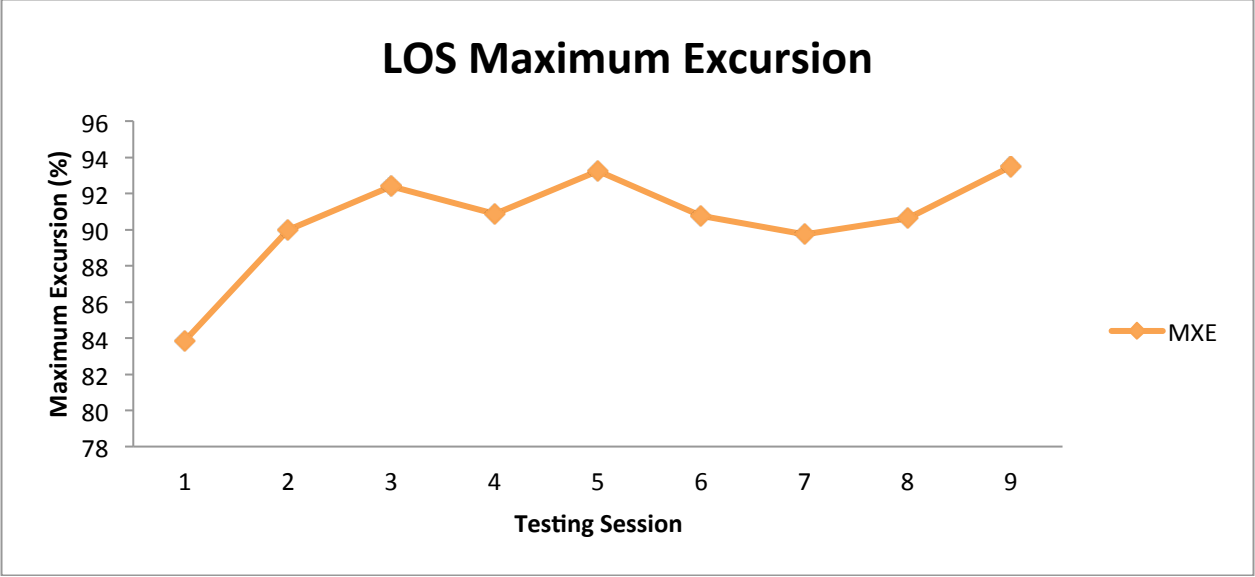
*Number 1 testing session represents the baseline score

Figure 11. Limits of Stability test. Recorded the distance from starting position to end target. Represented as a percentage of maximum distance (starting position to target spot).



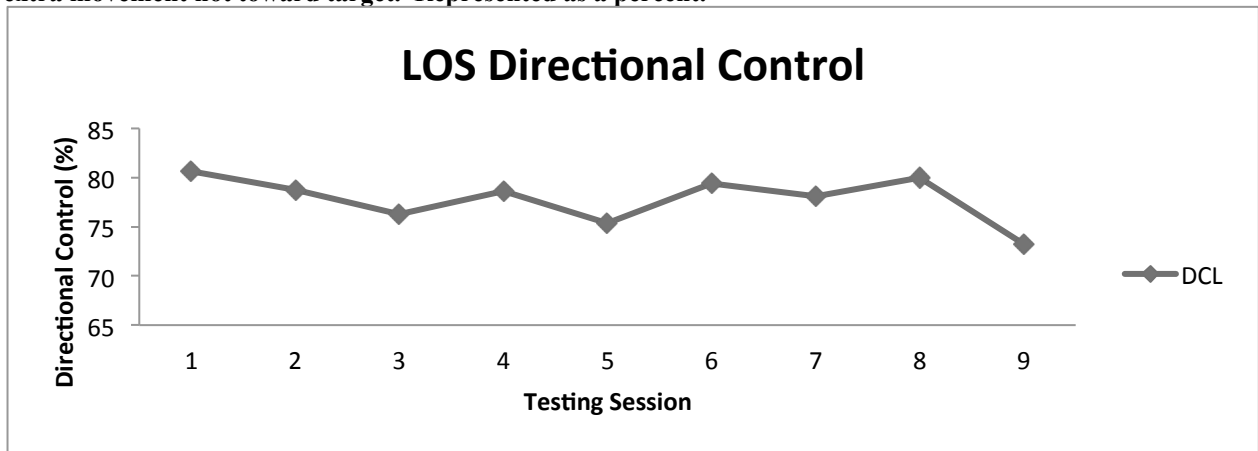
*Number 1 testing session represents the baseline score

Figure 12. Limits of Stability test. Recorded of the maximum distance achieved. Again reported as a percent of total distance from starting position to target location.



*Number 1 testing session represents the baseline score

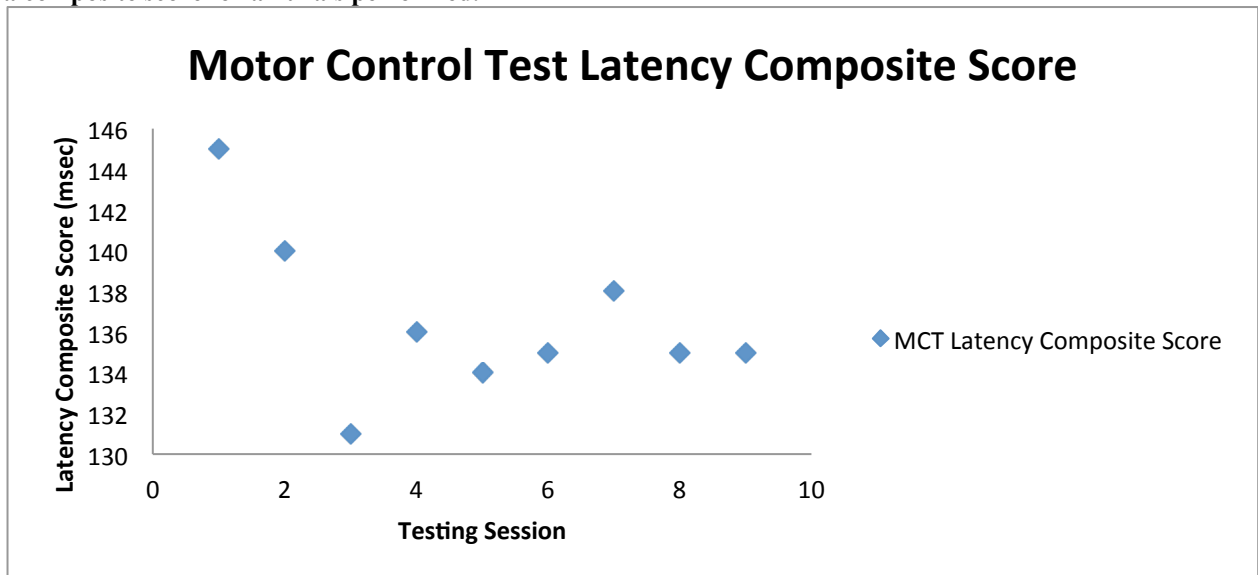
Figure 13. Limits of Stability test. Directional control compares amount of movement toward target with extra movement not toward target. Represented as a percent.



*Number 1 testing session represents the baseline score

The NeuroCom Motor Control Test (MCT) examined the participant’s ability to respond to an unexpected stimulus. The data is reported as a latency score which illustrates the milliseconds it takes for the participant to respond and return to an upright posture. The composite scores for the MCT shows a decrease in latency score over time. The participant took less time to respond to the disturbance from baseline to final observation (see Figure 14).

Figure 14. Motor Control Test. Recorded time between disturbance and reaction to stimulus. Represented as a composite score for all trials performed.



*Number 1 testing session represents the baseline score

DICUSSION

The data presented in this case study shows predictable results in terms of recovery from a total knee arthroplasty. Functional outcomes and other observed measures in general demonstrated a steep decline post-surgery and then improved as the observation period continued. In some cases, functional outcomes improved above pre-surgery levels. These declines are typical follow a total knee replacement.

This study was largely concerned with the potential effect of the continuous femoral nerve block on the right leg compared to the left leg which did not have a continuous nerve block. The EMG data shows similar patterns for both right and left leg's VMO. The right leg shows higher RMS values throughout the observation period which suggests that there was better detection of the VMO contraction on the right leg compared to the left leg. The left leg declines further post surgery but then returns to levels similar to the right leg around the 7th testing session which was approximately two months post surgery. The right leg (continuous femoral nerve block leg) shows a drop in EMG VMO activation but then begins to improve at the one month post-surgery mark.

This data suggests that the nerve block may not have had as great of an effect as initially predicted. Continuous femoral nerve blocks are used in order to mediate post-operative pain especially in patients undergoing total knee arthroplasty. These types of nerve blocks are favored over other methods of analgesia due to their success in decreasing pain following surgical intervention (Chelly, et.al., 2001). There is limited data available on the potential affect that the nerve blocks may have on muscle reactivation. This study suggests that there was little difference between the nerve block leg (right leg) and the non-nerve block leg (left leg), in terms of muscle activation following surgery.

There are multiple limitations in this data. During surgery, the VMO tendon was split in order to access the knee joint, which would affect the reactivation of the VMO following surgery. This can be seen in the steep decline of EMG activation from baseline to first post-operative test. The EMG may not have accurately detected muscle activation due to the interference that the skin and subcutaneous fat may have caused. Also the electrodes may not have been placed in the exact same place at each testing session. Other limitations in this case study were present.

During surgery in this particular case, the participant sustained a tibial plateau fracture to his left leg which could have had an effect on the return of the left leg's function. The participant was unable to bear weight on the left leg for four weeks following surgery due to the fracture. The fracture may have caused a delay in the ability to complete the prescribed rehabilitative protocol for TKA. This may explain the initial difference between the right and left legs.

Varying scores in the EMG data also affected the ability to determine the true difference between right and left sides. More data is needed to determine the effect of continuous femoral nerve blocks on the activation of the quadriceps muscle following TKA surgery.

The NeuroCom data was used to show functional capabilities of the patient. The forward lunge test in particular was a key test in this case study. Comparison of right and left legs in the forward lunge showed similar results. When compared to the right leg the left leg had a higher impact index throughout almost the entire observation period until the final testing session when the left leg and right leg impact indexes were about equal. This may mean that the subject favored one leg over the other, or felt more stable on the left leg compared to the right. This may suggest that the left leg is the subjects more dominant leg.

The other functional test using the NeuroCom System provided data that was predictable for a patient who is returning from surgery. In general they showed a sharp decline in ability immediately following surgery and then a steady improvement over the 12 month observation period. In some cases there was some non-uniform improvement which could be explained by learning and familiarity with the tests, distraction from task at hand, and/or participant fatigue.

The KOOS survey provided a self report of the participants overall symptom and disability score. Over the course of the observation period the participant reported improvement in all areas evaluated in the test. The KOOS survey evaluates five areas associated with knee pain and disability. These areas include: pain, symptom, activities of daily living, sports/recreation and quality of life (KOOS User's Guide, 2012). The participant's scores improved drastically over the course of the observation period. The scores for the final survey were much higher than the baseline scores. This may suggest that the total knee replacement was successful in improving the participant's quality of life.

This case study does not suggest that there is a notable difference between VMO activation between the continuous femoral nerve block leg and the non-nerve block leg. The participant showed a typical recovery pattern for a patient that has undergone TKA. More studies are needed in order to determine if there should be a concern with the use of continuous femoral nerve blocks and their affect on quadriceps activation and recovery of surgical patients. Due to this study's design the results are not applicable to any population besides the participant in this particular case study. Some suggestions for further research of this topic include the study of TKA patients or ACL patients who receive a continuous femoral nerve block and those who don't.

APPENDIX A

Appendix A contained a copy of the surgeon's and evaluation of the patient; patient's knee X-Rays, and the operative report for the participant's simultaneous bilateral total knee arthroplasty. The operative report described the diagnosis, procedure performed, implants used and what specifically occurred during surgery.

MEDICAL DOCUMENT

This document is for Clinical Us

Patient Name: ██████, ██████ R

Operative Report (11/15/2011 00:00)

(Status: Final)

Date of Service: 11/15/2011

SURGEON: ██████

FIRST ASSISTANT: ██████ M.D.

SECOND ASSISTANT: ██████ PA-C

PREOPERATIVE DIAGNOSIS: Bilateral knee degenerative joint disease.

POSTOPERATIVE DIAGNOSIS: Bilateral knee degenerative joint disease.

ADDITIONAL DIAGNOSIS: Left tibial plateau fracture.

SECONDARY DIAGNOSIS: Hypertension.

PROCEDURE PERFORMED: Bilateral total knee arthroplasty, navigational. Left tibial open reduction internal fixation medial tibial plateau fracture.

ANESTHESIOLOGIST: ██████

ANESTHESIA: Right continuous femoral nerve block and spinal.

FINDINGS: Severe lateral compartment degenerative joint disease bilaterally, iatrogenic left tibial plateau fracture from previous ACL anterior tunnel.

TOURNIQUET TIME: Left tourniquet time 121 minutes at 300 mmHg. Right tourniquet time 95 minutes at 300 mmHg.

IMPLANTS: Left Stryker triathlon #5 femur, cemented #5 tibia, 11 mm X3 poly and a 33 x 9 mm patella. Right Stryker triathlon #4 femur cemented, #4 tibia cemented, universal baseplate, 11 mm X3 poly insert, and 33 x 9 mm patella.

INDICATIONS FOR PROCEDURE: The patient is a 53-year-old male with bilateral valgus deformities consistent with posttraumatic arthritis. He has had previous ACL reconstructions bilaterally. His clinical exam and pain are consistent with bilateral degenerative joint disease of his knees. Risks and benefits of surgery

Logan Regional Hospital



Operative Report

ROOM:

DOB: 06/01/1958

AGE: 53Y Age At Date Of Note

MEDICAL DOCUMENT

This document is for Clin

Patient Name: ~~XXXXXXXXXX~~

were explained to the patient to include nerve, artery, tendon damage, infection, need for additional surgery, loss of motion, pain, and scarring. All questions were answered, informed consent was obtained.

DESCRIPTION OF PROCEDURE: The left knee was identified as the correct operative site. A timeout procedure was accomplished. The patient had previously undergone right continuous femoral nerve block and spinal anesthesia. The bilateral lower extremities were prepped and draped. The right one was prepped and draped off. The left lower extremity was then exsanguinated. Navigational protocol distal femur, navigational pins and tibial pins were placed. Appropriate referencing guides were then accomplished. There was noted to be preoperatively 4 degrees of varus in extension and also valgus at 30 degrees approximately 3 degrees. His range of motion was approximately 0-132 degrees. Distal femur was resected and sized to a 5. The tibia was then delivered, measured, and resected taking approximately 9 mm off the least affected side, which would be the most of the medial side with approximately 3 degrees of posterior slope. There was a large anterior hole. This was cleaned. The posterior osteophytes and soft tissue balancing was then accomplished. With less than 2 degrees of varus through range of motion, this was felt to be adequate. The patella was measured and resected, leaving a residual 14 and sized to a 33. Trial components were placed. The knee was placed through range of motion with approximately 2.5 degrees of varus through range of motion and 0-135 degrees range of total motion. The cement was prepared on the back table, the tibial component was cemented. As the tibial component was cemented, there was noted to be a cement coming out in the anterior aspect of the tibia and as this was pressurized, there was noted to be a crack that was noted medially and was approximately 25% of the anterior medial aspect of the tibia. The distal one was followed. A 3.5 mm lag screw was then placed from medial to lateral to reinforce this with good purchase. This was felt to be relatively stable. The femur was then cemented. Excess cement had been removed and the patella was cemented and excess cement removed. The cement was allowed to harden. The range of motion was 0-133 degrees. Excess cement was removed. The knee was copiously irrigated. The final 11 mm insert was placed. There was normal patella alignment. The medial arthrotomy was closed with #2 Force Fiber, #1 Vicryl. The subcutaneous tissues were closed with 0 Vicryl, 2-0 Vicryl, and staples to the skin. The tourniquet was deflated. The patient received 2 g Ancef preoperatively Attention was then directed to the right knee. Identical procedure was accomplished. Preoperative information showed a range of motion of approximately 0-128 degrees with 0 degrees of varus in extension and valgus at 4 degrees and 30 degrees. The final components in this knee were force cruciate retaining cemented Stryker femur and a #4 universal tibial base plate cemented and 33 x 9 mm cemented #4, 11 mm insert CS. Identical procedure was accomplished. Soft tissue balancing was done, navigational protocol was used. The final results showed 0-133 range of motion of varus at 2 degrees and through range of motion, which was consistent. Excess cement was removed after the components

Logan Regional Hospital

ROOM:



Operative Report

DOB: 06/01/1958

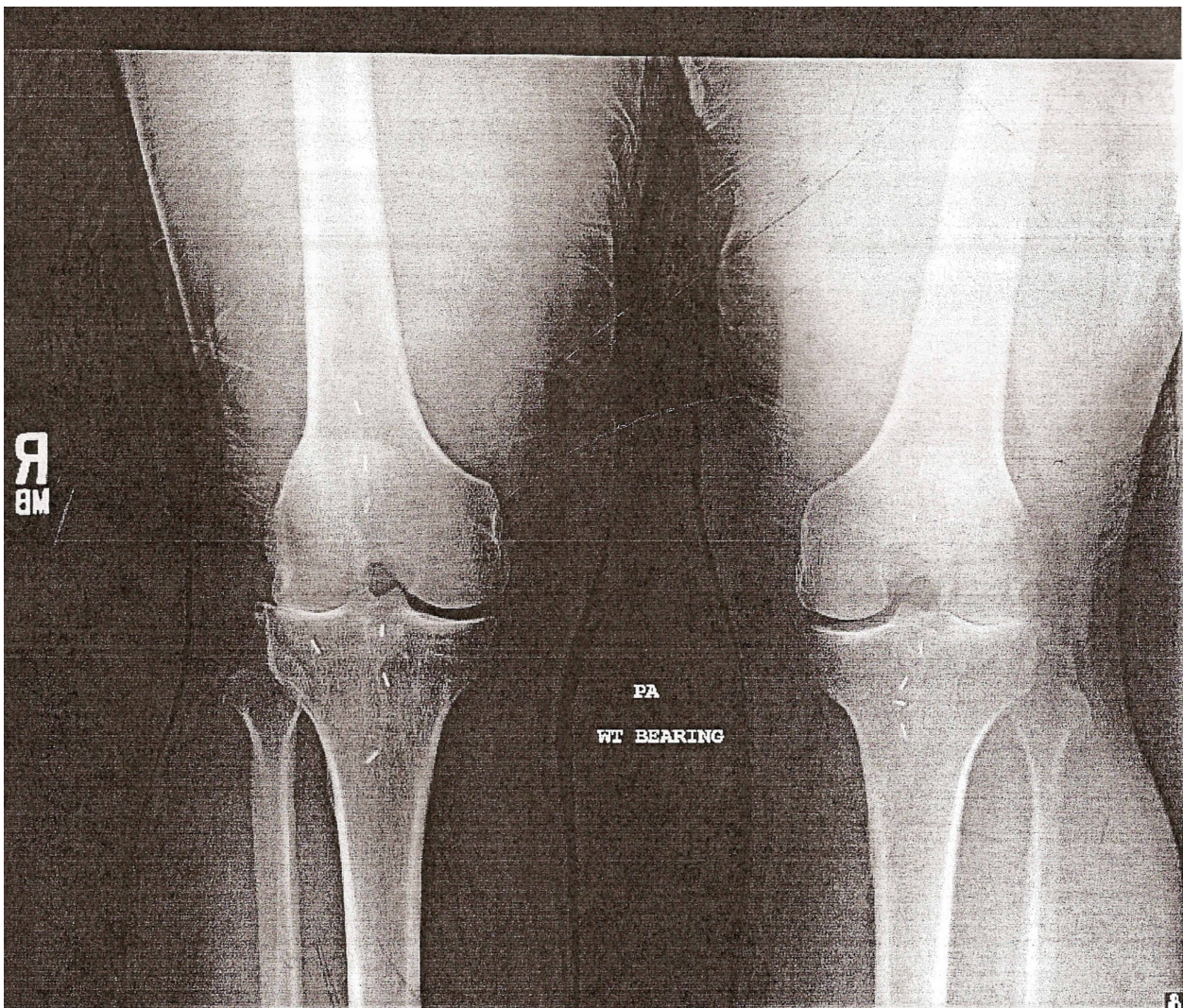
AGE: 53Y Age At Date Of Note

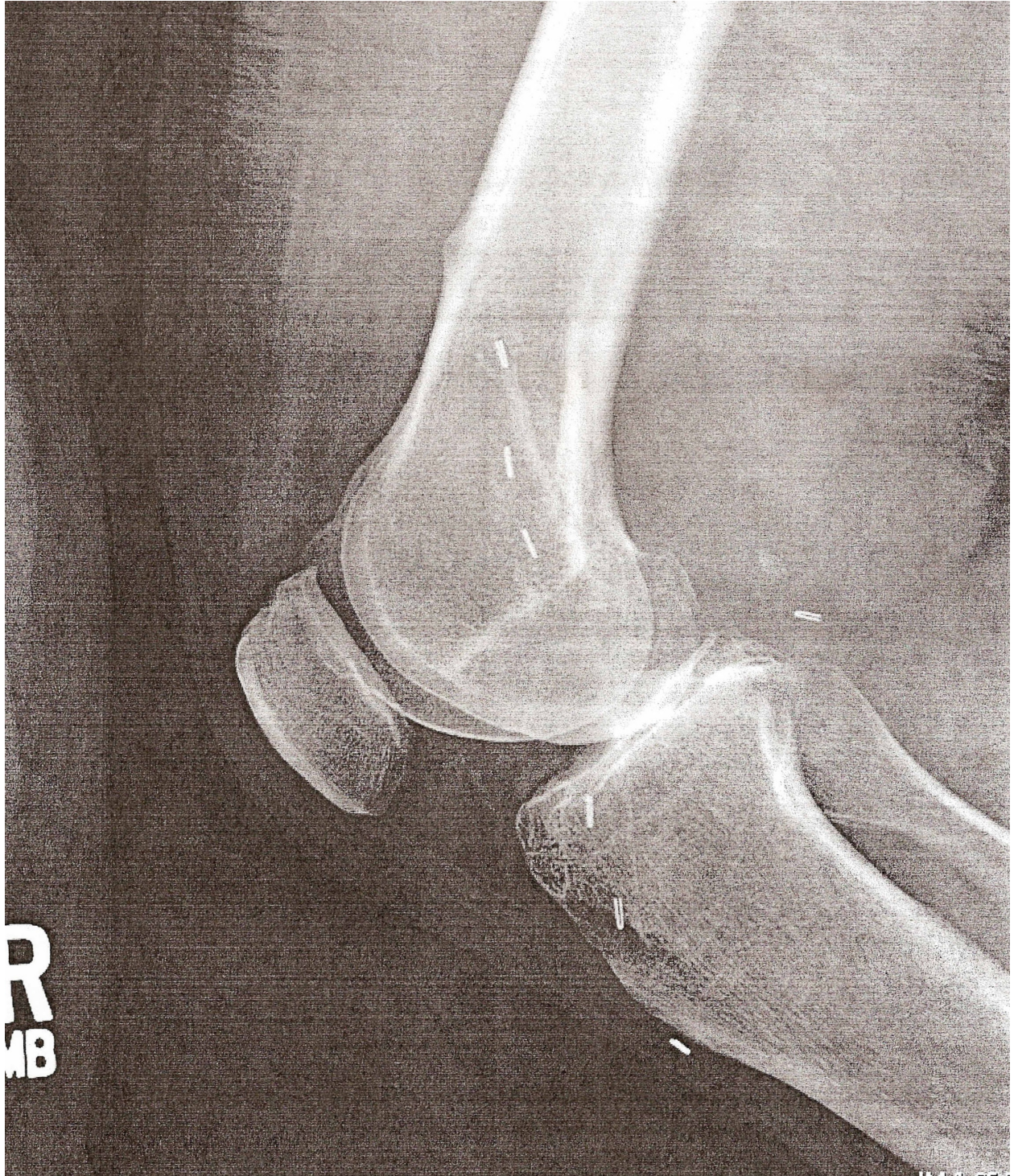
MEDICAL DOCUMENT

Patient Name: ~~DAVID BRADY~~

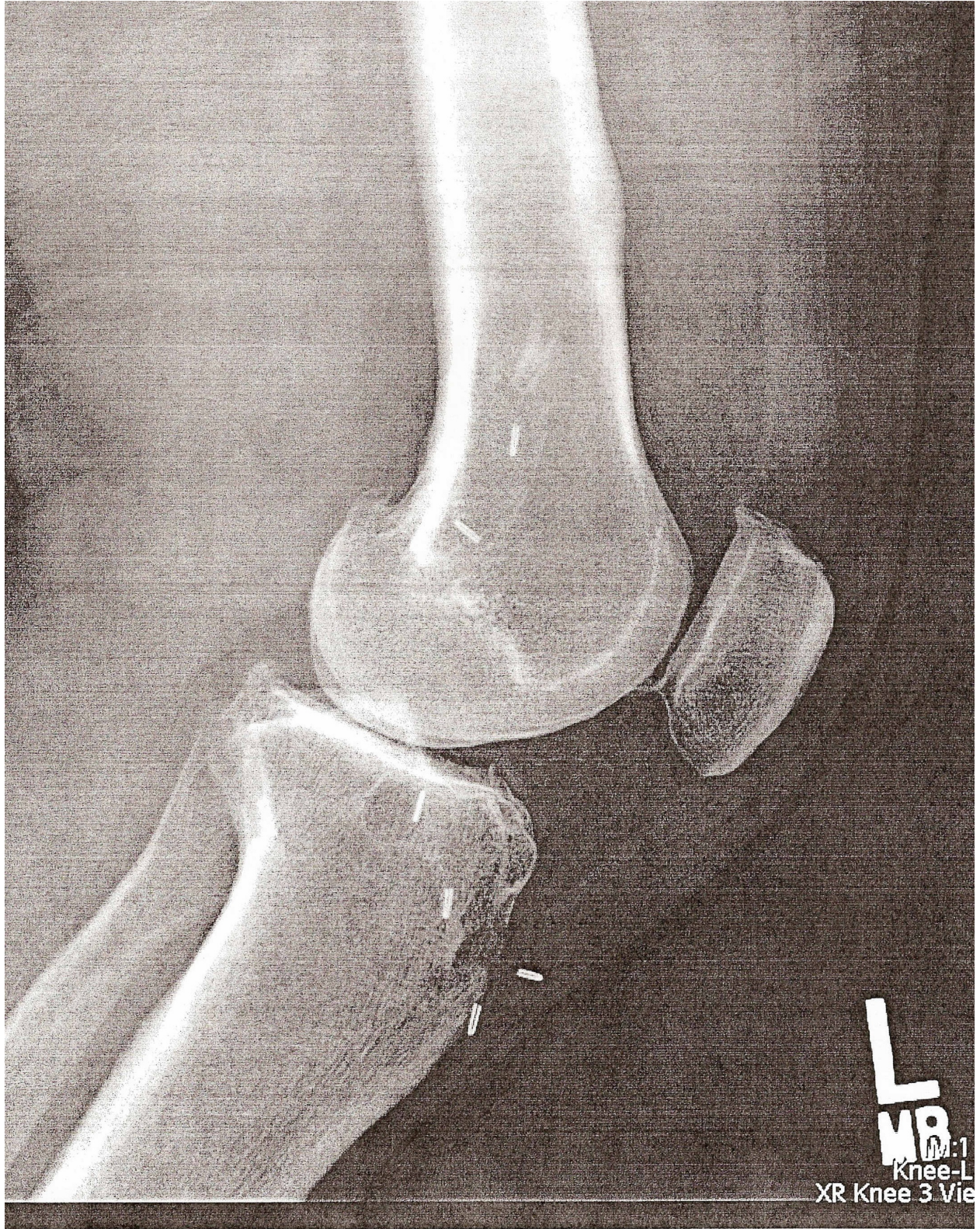
were then withdrawn. The medial arthrotomy was closed with #2 Force Fiber, #1 Vicryl, subcutaneous tissues 0 Vicryl, 2-0 Vicryl, and staples to the skin.

Rehab will be full weightbearing right lower extremity and 75% weightbearing, left lower extremity.





R
MB



APPENDIX B

Appendix B contained a copy of a physical therapy assessment sheet. This sheet was used to record subjective and objective information on the participant's progress through rehabilitation from simultaneous bilateral total knee arthroplasty. Common assessments seen on this sheet include rating of pain, girth measurement, range of motion and strength measurements, and the KOOS Survey.

Physical Therapy - General Report (11/21/2011 00:00)

(Status: Preliminary)

Date of Service: 11/21/2011

PHYSICIAN: Dr. Brian King

DIAGNOSIS: Status post bilateral total knee replacement.

SUBJECTIVE: The patient has been referred to physical therapy by Dr. [REDACTED] following him receiving bilateral TKA that was performed on November 15, 2011. The patient had surgery on Tuesday and was in the hospital until Friday. He has been home over the weekend and states that he has been doing well following the surgery. He rates his pain in both knees at a 5/10 today. He did receive EMG testing through the < ____? ____ > department, both on Friday and Monday and see attached results. The patient is currently using crutches bilaterally and states that he is supposed to be partial weightbearing on his left knee due to a fracture in the tibial plateau. Doctor has told him 75% weightbearing on this knee for at least 4 weeks.

OBJECTIVE:

OBSERVATION: The patient's incisions appear to be healing and free from infection at this time. He has staples present in each of the incisions. He has been changing the dressings on his own.

GIRTH: The patient's mid patellar girth on the left side is 17 inches, on the right 17-1/2, 3 inches superior to patella is 19 inches on the left, 19-1/4 on the right.

RANGE OF MOTION: Active range of motion on the left 78 degrees, on the right 68 degrees, passive range of motion on the left, flexion 88 degrees and on the right 80 degrees, extension and on the left is -7 degrees and on the right -12 degrees.

STRENGTH: The patient was unable to perform a straight leg raise on the left side today. The patient was able to do a straight leg raise on the right independently with 10-15 degrees extensor lag.

TIMED UP AND GO: The patient's timed up and go time of 35.1 seconds today and he was using crutches bilaterally.

TREATMENT PROVIDED: Today included range of motion exercises including heel slides, as well as walking 1 lap around the clinic. He was given electrical stimulation accompanied with ice as well today. The patient does have a home neuromuscular

Logan Regional Hospital



Physical Therapy - General Report

ROOM:

DOB: 06/01/1958

AGE: 53Y_{Age At Date Of Note}

electrical stimulation unit that he has been using on a regular basis as well as he has been using a Game Ready and the CPM on a regular basis throughout the day independently.

ASSESSMENT:

IMPRESSION: The patient appears to be recovering well following his bilateral TKAs. He does appear to have difficulty performing straight-leg raise today on the left side compared to the right. The patient will respond well to physical therapy to decrease swelling and pain present in the knees as well as to restore functional activity including walking, and going up and down stairs as well as just normal functional strength.

REHABILITATION POTENTIAL: The patient has good rehab potential to achieve all physical therapy goals. If patient is compliant with treatment and physician protocol, he should respond well and return back to his prior level of activity.

PROBLEM LIST:

1. The patient has decreased range of motion in both flexion and extension today.
2. The patient has decreased strength throughout his quadriceps and lower extremities in general.
3. The patient is unable to ambulate without the use of crutches bilaterally.
4. The patient is unable to perform activities such as squatting, sit to stand, and/or going up and down stairs without assistance at this time.


SHORT TERM GOALS TO BE MET IN 1-2 WEEKS:

1. Restore range of motion to 0 degrees extension and 120 degrees flexion.
2. The patient able to ambulate with 1 crutch with good balance.
3. The patient able to perform a straight-leg raise without extensor lag with his knees bilaterally.

LONG TERM GOALS TO BE MET IN 6-8 WEEKS:

1. The patient able to ambulate with a good walking stride without the use of assistive devices.
2. Restore range of motion to 0-130 degrees.
3. Strength 5/5 throughout the quadriceps in the lower extremity in general.
4. Restore patient's balance as well as strength prior to surgery baseline measurements.

PLAN: The patient will be seen 1-2 times a week for modalities as needed for pain

 Intermountain Healthcare	Logan Regional Hospital Physical Therapy - General Report	ROOM: DOB: 06/01/1958 AGE: 53Y Age At Date Of Note
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and inflammation accompanied with therapeutic exercises of range of motion and strengthening exercises. This will be accompanied with balance and proprioception type exercises, as well as underwater treadmill aquatic workouts.

Thank you for this referral.

**Knee injury and Osteoarthritis Outcome Score (KOOS), English version LK1.0 1
KOOS KNEE SURVEY**

Today's date: ____/____/____ Date of birth: ____/____/____

Name: _____

INSTRUCTIONS: This survey asks for your view about your knee. This information will help us keep track of how you feel about your knee and how well you are able to perform your usual activities.

Answer every question by ticking the appropriate box, only one box for each question. If you are unsure about how to answer a question, please give the best answer you can.

Symptoms

These questions should be answered thinking of your knee symptoms during the last week.

S1. Do you have swelling in your knee?

Never

Rarely

Sometimes

Often

Always

S2. Do you feel grinding, hear clicking or any other type of noise when your knee moves?

Never

Rarely

Sometimes

Often

Always

S3. Does your knee catch or hang up when moving?

Never

Rarely

Sometimes

Often

Always

S4. Can you straighten your knee fully?

Always

Often

Sometimes

Rarely

Never

S5. Can you bend your knee fully?

Always

Often

Sometimes

Rarely

Never

Stiffness

The following questions concern the amount of joint stiffness you have experienced during the last week in your knee. Stiffness is a sensation of restriction or slowness in the ease with which you move your knee joint.

S6. How severe is your knee joint stiffness after first wakening in the morning?

None

Mild

Moderate

Severe

Extreme

S7. How severe is your knee stiffness after sitting, lying or resting later in the day?

None

Mild

Moderate

Severe

Extreme

Knee injury and Osteoarthritis Outcome Score (KOOS), English version LK1.0 2

Pain

P1. How often do you experience knee pain?

Never

Monthly

Weekly

Daily

Always

What amount of knee pain have you experienced the last week during the following activities?

P2. Twisting/pivoting on your knee

None

Mild

Moderate

Severe

Extreme

P3. Straightening knee fully

None

Mild

Moderate

Severe

Extreme

P4. Bending knee fully

None

Mild

Moderate

Severe

Extreme

P5. Walking on flat surface

None

Mild

Moderate

Severe

Extreme

P6. Going up or down stairs

None

Mild

Moderate

Severe

Extreme

P7. At night while in bed

None

Mild

Moderate

Severe

Extreme

P8. Sitting or lying

None

Mild

Moderate

Severe

Extreme

P9. Standing upright

None

Mild

Moderate

Severe

Extreme

Function, daily living

The following questions concern your physical function. By this we mean your ability to move around and to look after yourself. For each of the following activities please indicate the degree of difficulty you have experienced in the last week due to your knee.

A1. Descending stairs

None

Mild

Moderate

Severe

Extreme

A2. Ascending stairs

None

Mild

Moderate

Severe

Extreme

Knee injury and Osteoarthritis Outcome Score (KOOS), English version LK1.0 3

For each of the following activities please indicate the degree of difficulty you have experienced in the last week due to your knee.

A3. Rising from sitting

None

Mild

Moderate

Severe

Extreme

A4. Standing

None

Mild

Moderate

Severe

Extreme

A5. Bending to floor/pick up an object

None

Mild

Moderate

Severe

Extreme

A6. Walking on flat surface

None

Mild

Moderate

Severe

Extreme

A7. Getting in/out of car

None

Mild

Moderate

Severe

Extreme

A8. Going shopping

None

Mild

Moderate

Severe

Extreme

A9. Putting on socks/stockings

None

Mild

Moderate

Severe

Extreme

A10. Rising from bed

None

Mild

Moderate

Severe

Extreme

A11. Taking off socks/stockings

None

Mild

Moderate

Severe

Extreme

A12. Lying in bed (turning over, maintaining knee position)

None

Mild

Moderate

Severe

Extreme

A13. Getting in/out of bath

None

Mild

Moderate

Severe

Extreme

A14. Sitting

None

Mild

Moderate

Severe

Extreme

A15. Getting on/off toilet

None

Mild

Moderate

Severe

Extreme

Knee injury and Osteoarthritis Outcome Score (KOOS), English version LK1.0 4

For each of the following activities please indicate the degree of difficulty you have experienced in the last week due to your knee.

A16. Heavy domestic duties (moving heavy boxes, scrubbing floors, etc)

None

Mild

Moderate

Severe

Extreme

A17. Light domestic duties (cooking, dusting, etc)

None

Mild

Moderate

Severe

Extreme

Function, sports and recreational activities

The following questions concern your physical function when being active on a higher level. The questions should be answered thinking of what degree of difficulty you have experienced during the last week due to your knee.

SP1. Squatting

None

Mild

Moderate

Severe

Extreme

SP2. Running

None

Mild

Moderate

Severe

Extreme

SP3. Jumping

None

Mild

Moderate

Severe

Extreme

SP4. Twisting/pivoting on your injured knee

None

Mild

Moderate

Severe

Extreme

SP5. Kneeling

None

Mild

Moderate

Severe

Extreme

Quality of Life

Q1. How often are you aware of your knee problem?

Never

Monthly

Weekly

Daily

Constantly

Q2. Have you modified your life style to avoid potentially damaging activities to your knee?

Not at all

Mildly

Moderately

Severely

Totally

Q3. How much are you troubled with lack of confidence in your knee?

Not at all

Mildly

Moderately

Severely

Extremely

Q4. In general, how much difficulty do you have with your knee?

None

Mild

Moderate

Severe

Extreme

Thank you very much for completing all the questions in this questionnaire.

APPENDIX C

Appendix C contained a literature review that was completed prior to the beginning of the study. It provided background information on total knee arthroplasty and anesthesia techniques.

LITERATURE REVIEW

Osteoarthritis (OA) is a debilitating condition that affects a large population around the world. In the United States, OA is one of the leading causes of functional disability, and its occurrence is steadily rising (Mizner, Petterson, & Snyder-Mackler, 2005). There are four grades associated with the degree of degeneration that occurs with OA. Grade one is described as a softening of the cartilaginous structures. Grade two shows fibrillation or fraying of the cartilage. Grade three is all of the above along with signs of cracking in the cartilage. Grade four includes all of the previous grades with the addition of exposed bone. There are many factors that play into the development of osteoarthritis including normal joint wear and tear, genetics, trauma, infection and autoimmune disorders (CDC, 2011).

Osteoarthritis is primarily seen in an older population, usually middle-aged to the elderly. However, presentation of OA in a younger, active population is becoming more common. In recent studies it has been reported that 12-14 years following an ACL rupture approximately 50% of people are showing arthritic changes in the knee similar to OA patients (Sward, Kostogiannia, von Porat, Boegard, & Roos, 2009). Factors that may influence the progression of OA following a traumatic event include: meniscal or articular cartilage damage, subchondral bone damage, poor biomechanics, chronic laxity, 'giving-way' episodes, and low-grade synovitis (Sward, et.al., 2009).

Total knee arthroplasty (TKA) is a common treatment of OA in the knee. A prosthetic device replaces the knee joint. The goal of TKA is to improve functional outcomes of the patient (Barbay, 2009). While the quality of the patient's life generally improves following joint replacement therapy, there are surgical risks (see Appendix C) (Mizner, et.al., 2005, Noble, et.al., 2009, Akhtar, & Houlihan-Burne, 2010).

One of the four most serious complications is deep vein thrombosis or DVT (Noble, Goodall, & Noble, 2009). Other risks from surgery include infection, cardiac complications, deafness, death, gastro-intestinal bleeding, thrombo-embolism, and stroke. Transfusion needs from excessive blood loss is also a potential complication (Noble et.al., 2009). Overall patients who have had a successful TKA surgery, have reported a significant decrease in pain and improvement in physical function (Mizner, et.al., 2005, Noble, et.al., 2009, Akhtar, & Houlihan-Burne, 2010).

There are different techniques for TKA especially in terms of anesthesia and pain control. Traditionally general anesthesia that involves a ‘single-shot’ spinal technique is useful in providing sufficient pain relief for the patient. In SBTKR, this technique is not ideal because it does not last long enough to complete both knee replacements (Noble, et.al., 2009). The traditional anesthesia technique for SBTKR involves a combined spinal-epidural procedure, which allows regional pain control. This technique is beneficial because both general and regional anesthesia can be utilized, and use of an epidural catheter allows for continued localized pain control following surgery (Noble, et.al., 2009).

Postoperative analgesia techniques may also include patient-controlled analgesia using morphine, epidural analgesia (discussed above) and nonsteroidal anti-inflammatory drugs. These techniques have proven to be effective in pain control; however, significant side effects have been reported. These side effects include: respiratory depression, constipation, nausea and vomiting (Noble, et.al., 2009). Due to these often severe side effects, TKA postoperative pain control techniques need to be evaluated and improved.

Continuous femoral infusion is becoming a common technique used for post-operative pain management following a TKA. The major downside to CFI is the management of the

catheters. Time, effort and cost to monitor and utilize CFI catheters pose some issues (Salinas, et.al., 2006). Overall continuous femoral nerve blocks have resulted in lower pain scores compared to other pain control techniques, which may facilitate earlier physical therapy (Chelly, et.al., 2001; Salinas, et.al., 2006). Pain following TKA is the greatest limiting factor in beginning early application of rehabilitation, therefore with better pain control measures, recovery time may decrease (Chelly, et.al., 2001; Salinas, et.al., 2006).

Measuring functional outcomes of TKA is important in monitoring the success of these surgeries. Tools that should be used to determine TKA success include disease-specific measurement tools, patient-specific assessment tools, functional capacity measures, and cost-benefit assessments (Bourne, 2008). Common tools for patient-specific and disease-specific assessment include self-assessment questionnaires like the Short Form-36 Health Questionnaire (SF-36) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). Functional capacity testing includes tests like 6-minute walk, 30-second stair climb, knee injury and osteoarthritis outcome score (KOOS), Knee Outcome Survey-Activities of Daily Living Scale (KOS-ADLS) and Timed Up-and-Go. Other important measures for determining the success of TKAs include knee ROM measurements, isometric strength and isokinetic strength assessment (Bourne, 2008; Mizner, et.al. 2005). All measures should be assessed prior to surgery and then continually updated as progress is made.

Typical TKA rehabilitation protocols begin immediately following surgery (See Table 1>). There are different phases of rehabilitation. Each phase focuses on a improving upon certain outcomes and meeting goals. Generally there are four phases to the recovery and rehabilitation process. These include: Phase I-Immediate Post-Operative Phase days 1-10; Phase II-Motion Phase weeks 2-6; Phase III-Intermediate Phase weeks 7-12; Phase IV-Advanced

Activity Phase weeks 14-26 (Tingstad; Intermountain, 2009). Each rehabilitative phase can be further broken down into more specific goals and specific exercises (Tingstad; Intermountain, 2009).

Phase I goals include: improving passive knee extension to 0° , active quadriceps contraction, independent ambulation, knee flexion to 90° or greater, and control of swelling and bleeding (Tingstad; Intermountain, 2009).

Phase II will begin after the goals from Phase I have been met. The goals of Phase II build upon Phase I. They include: improving ROM, enhance muscular strength and endurance, improve dynamic joint stability, diminish swelling/inflammation, create a guideline for return to functional activity and improve overall health (Tingstad; Intermountain, 2009).

Progression to Phase III is next once Phase II bench marks are met. Phase III focuses on: continued increase of ROM from $0-115^{\circ}$ and greater, continued improvement of strength and endurance, concentric and eccentric control of knees, increase cardiovascular endurance, and performance of functional activities (Tingstad; Intermountain, 2009).

The final phase of the rehabilitation protocol focuses on advancement of functional activities and improvement of activities of daily living. Specifically the goals of Phase IV include: allow advanced recreational activities, continue to maintain and improve strength and endurance, and return to activities of daily living (Tingstad; Intermountain, 2009).

Compared to other anesthesia methods, there is some question as to whether CFI delays the ability to activate the quadriceps muscles following TKA. This question is based largely on anecdotal evidence. The femoral nerve block temporarily affects the nerve activation and if the anesthesia does not wear off within a reasonable amount of time, then the firing of the femoral nerve and its branches may have been delayed. If quadriceps activation is delayed due to the

anesthesia there is question whether functional outcomes will be affected. There is a high correlation to functional performance and the activation of the quadriceps (Mizner, et.al., 2005). By improving the strength of the quadriceps, the outcomes of a TKA also improve (Mizner, et.al., 2005). Since quadriceps weakness persists following TKA, it is imperative that the rehabilitation program focus on increasing quadriceps strength in order to improve function of the patient (Greene, et.al., 2008; Mizner, et.al., 2005).

The effect of CFI on quadriceps muscle activation and reactivation is not well understood. There is anecdotal evidence that the use of CFI in TKA and ACL patients may delay reactivation of the quadriceps muscle, which may in turn delay initial progress of rehabilitation and return to functional activity. The purpose of this study is to determine the effects of femoral nerve block use during total knee arthroplasty on the return of quadriceps activation and functional outcomes. This study will focus on an individual case consisting of simultaneous bilateral knee replacement. The individual will receive a femoral nerve block in one knee and traditional anesthesia in the other. We will consider the improvement in functional outcomes following surgery. It is hypothesized that the femoral nerve block will delay the activation of the quadriceps muscle and the return of functional measures. However, the femoral nerve block will modulate pain more successfully compared to the standard pain control procedures. Do femoral nerve blocks delay activation of the quadriceps following TKA? If so, for how long is quadriceps activation delayed? Is return of balance and proprioceptive control delayed following use of a femoral nerve block during TKA?

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