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Methods of Hip Abductor Muscles Evaluation after Nailing of Proximal Femoral Fractures (PFF): A Short Review

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Abstract

Proximal femoral fractures representing a challenge for orthopaedic surgeons, as most of these fractures occur in elderly osteoporotic patients. Various methods of management had been reported, recently, cephalomedullary nailing (CMN) become the most popular method for management of such fractures. Although being highly successful, CMN still have some drawbacks such as persistent hip abductor weakness. In this short review, different methods of hip abductor muscles assessment were discussed.

Keywords: Hip abductor; evaluation; nailing; femoral fractures

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Introduction

Proximal femoral fractures (PFF) are frequently seen in daily orthopaedic practice, most commonly in elderly patients (1). Globally there are already more than 1.3 million hip fractures each year (2) which is expected to increase to 6 million annually by the year 2050. (3)

Different techniques for management of such fractures had been reported in the literature, but the use of cephalomedullary nails (CMN) for treating such fractures has gained enormous popularity since the early 1980s (4-6) because of minimal invasiveness, ease of surgery, and theoretical mechanical advantages, particularly in unstable fractures (7, 8).

Although CMN carries a high success rate, long term persistent complaints such as residual peri-trochanteric pain, stiffness, limping, limited walking distance, and difficulty with stairs have been reported and still a concern (9-13).

Studies of elderly adults have demonstrated that strength deficit affecting abductor muscles is extremely large after PFF (14, 15). Although literature reports this strength and power deficit to be as high as 50% (16-18) postoperative abductor weakness is often overlooked, Patients very often describe a lurch (or limp) in their gait, which is often missed by the surgeon, or the lurch is so mild that it may go unnoticed and becomes apparent only on close observation (19).

The objective of this short review is to highlight principal methods of hip abductor muscle evaluation after the nailing of PFF.

Applied Anatomy of Hip Abductors:

The proximal attachment of the gluteus medius starts from the anterior superior iliac spine and proceeds along the outer edge of the iliac crest to the posterior superior iliac spine. It inserts as a broad, flattened tendon on the anterosuperior portion of the greater trochanter (20). The average length of the gluteus medius tendon measures 55.9 mm and the average width measures 16.8 mm. The average surface area of the tendinous insertion on the trochanter measures 935 mm^2 (658–1294 mm^2) (21).

Evidence from previous anatomic studies suggests the insertion of the gluteus medius tendon does not insert broadly on the greater trochanter, but rather covers the posterior tip and extends laterally and anteriorly (22-24). The gluteus minimus inserts anteriorly on the greater trochanter, and between these two structures lies the sub-gluteus medius bursa (22, 25).

Methods of Evaluation:

MRI

Static MRI is used to document post-operative damage to the adjacent soft tissues around the entry points; edema, hematomas, fluid collections as well as lesions to the abductor muscles can be recorded (25).

Isokinetic Muscle Testing

Ansari et al. measured hip abductor apparatus isokinetically on a Cybex 6000© dynamometer for comparison with the uninjured side (26-28). After an initial 5 min of limbering up, the patients performed five external and internal rotations as forcefully as possible at a fixed speed of 30° and 60° per second. After a rest, they performed 15 consecutive external and internal rotations at 120° per second. To evaluate the endurance, values of the first five sets of movements were compared with the last five during a 120° per second test speed: Endurance ratio= last five (Nm)/first five (Nm). Peak torque values (Nm) in the injured limb were compared with the values obtained at the contralateral side and the difference was expressed as a percentage of the uninjured side. The percentage was considered to be negative when the peak torque was lower at the fractured side (27, 28). In the literature, the reliability coefficient of isokinetic Cybex measurements varies between 0.80 and 0.99 (29, 30).

Helmy., *et al*. measured quantitative isokinetic muscle strength using the KinCom® dynamometer (KinCom, Chattanooga Groups, Inc, Hixson, Tennessee) (31). A consistent configuration of straps, bolsters, and clamps was used to isolate the testing to the joint of interest. Each KinCom testing session began with a warmup and practice period. Patients were then preloaded to 80% of their maximal force to ensure optimal recruitment of motor units. The peak isokinetic torque was computed from the average of 3 repetitions. The hip abductors were tested bilaterally. They included testing of the knee extensors to determine whether antegrade nailing affected only muscles around the hip or produced a more global functional deficit within the limb (32).

Ivanova et al. measured the isometric strength of leg muscles 1 week and 6 months post-fracture with hand-held dynamometer Lafayette (USA), whereas the fractured leg was tested first. During the trials, the subjects sat on a chair. For measuring hip abduction, the hip and knee were flexed at 90°. The dynamometer pad was held at the lateral and medial femoral condyle respectively. The participants were asked to perform a maximal voluntary isometric contraction. Three trials were performed and the best trial was used for further analysis. Hip muscle weakness was quantified by comparing maximal voluntary isometric strength outcome between the fractured and nonfractured leg (2).

Manual Muscle Testing

The Trendelenburg test: patients who can balance using finger sup¬port only are asked to stand on one leg, flexing the other leg at the knee, while keeping the hip in extension. The Trendelenburg sign is investigated by posterior inspection after the identification of appropriate anatomic landmarks (32). The exam¬iner kneels in front of the patient to observe pelvic tilt. The test is negative when the unsupported pelvis is raised normally while standing on one leg and held there for at least 30 seconds (27, 28, 33, 34). In terms of hip kinetics, it is manifested as a decreased hip abduction angle and exaggerated lateral trunk lean (35). The Trendelenburg gait pattern or lateral trunk lean towards the affected extremity is a compensatory mechanism for the weakened hip abductor musculature. Furthermore, the modified McKay criteria are useful to assess if a patient has Trendelenburg gait. These criteria measure pain symptoms, gait pattern, Trendelenburg sign status, and the range of hip joint movement (19).

The abductor power of the patients is assessed according to the scale proposed by the Medical Research Council (MRC) (34).

EMG

The muscles are evaluated by the criteria of the American Academy of Electrophysiological Medicine for needle EMG: The vastus medialis, gastrocnemius, and extensor hallucis longus muscles are assessed to determine any evidence of spinal-originated problems. In order to exclude patients with polyneuropathy, radiculopathy, or plexopathy, nerve conduction studies of both lower extremities are performed.

Gluteus medius muscles are assessed bilaterally to evaluate the SGN, the vastus medialis muscle for L4 root, extensor hallucis longus muscle for L5 root, and gastrocnemius muscle for S1 root. First, resting activities are assessed for the signs of acute denervation (fibrillation and positive sharp waves), followed by observa¬tion of the recruitment pattern, the examination of the motor unit action potential (MUAP) amplitudes, and time characteristics. Finally, motor patterns of interferences are investigated during muscle contractions to obtain information about denervation and reinnervation of examined muscles. (27, 28, 34, 36)

Gait Analysis

Dujardin *et al*. reported on the interindividual variations in hip motion during normal gait (gait velocity, stride length, and abduction angle) (37).

Paul *et al*. used the Intelligent Device for Energy Expenditure and Gait analysis (IDEEA; MiniSun Inc, Fresno, CA), a portable microcomputer-based device to measure gait, postural movement, and energy expenditure. The device is noninvasive and consists of a small microprocessor clipped to a subject's belt with 5 sensors secured to the subject's body. The IDEEA has been previously validated for the evaluation of gait parameters (38). The IDEEA was applied to all patients at postoperative follow-up visits in the examination room as per the standardized protocol used in the validation trial. Patients were evaluated on a reserved 20-m flat course, and gait parameters were measured. Patients were allowed to use a cane for assistance and balance as needed. Parameters included single limb stance (SLS), cadence, cycle duration, stride length, and pulling acceleration (39).

Archdeacon *et al*. used three-dimensional gait analysis at 2 distinct time points [Time 1 = independent ambulation without ambulatory aide, 2.0 (60.6) months; Time 2 = approximately 6 months after injury with clinical and radiographic fracture healing, 7.2 (61.5) months] using a 3D-motion analysis system (Motion Analysis Corporation, Santa Rosa, CA) with 2 force plates (AMTI, Watertown, MA). The study subjects were instrumented with reflective markers using a modified Helen Hayes marker set with the static trial. (40) The video was collected at 240 Hz and time-synchronized with the force plates collected at 1200 Hz. Subjects were instructed to ambulate at a self-selected walking speed. Temporal-spatial, kinematic, and kinetic data were collected and normalized to 100% of the gait cycle, and kinetic data were also normalized to body mass (Nm/kg) (Visual 3D; C-Motion Inc. Rockville, MD). Temporal-spatial parameters included gait velocity (m/s), stride length (cm), and stride width. Hip and trunk kinematics included hip adduction angle° and lateral trunk lean°. Hip kinetics included hip abductor moment (Nm/kg) (35).

Helmy *et al*. collected motion data with an 8 Eagle camera Motion Analysis (Santa Rosa, California) real-time system using EvaRT 4.1 software. Analog data that were collected simultaneously include Force (or Kinetic) data via 2 AMTI (Amherst, Massachusetts) force platforms (OR 6-5) mounted in the center of the motion capture volume and their amplifiers (SGA6-4) and 16 channels of telemetered electromyography (EMG) using two Noraxon Telymyo systems. A modified Helen Hayes marker set that consisted of 30 retro-reflective markers for the static trial and 26 markers for the dynamic (walking) trials were affixed over key anatomic landmarks. This marker set is a full-body marker set that includes arms and trunk motion. Motion data were collected at 60 Hz. Force and electromyography (EMG) data were collected via an A/D interface board at a rate of 1200 Hz and were time matched to the motion data by EvaRT. Motion data were filtered in EvaRT at 6 Hz and then saved for postprocessing. Postprocessing of the motion and force data was done in Orthotrak 6.0 (Motion Analysis Corp, Santa Rosa, California). Orthotrak calculates temporal-spatial characteristics. Temporal spatial data included single-leg support time and step length, whereas kinetic and kinematic data included hip abductor movement and pelvic obliquity. Joint angles, joint forces, and internal joint moments were also calculated. (32)

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