

Functional performance of the knee after intraarticular anesthesia

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ABSTRACT

Ten healthy young volunteers underwent gait analysis and tests of knee joint position sense. Gait analysis included determination of stride characteristics (velocity, cadence, gait cycle, stride length, and single limb support time), force plate analysis, and motion analysis of the knee. The tests of joint position sense examined the ability of the subject to reproduce passive positioning of the knee and the ability to detect change in angle at the knee joint. In a double-blind manner, 10 cc of sterile fluid were injected into the left knee of each volunteer. Five received 2% lidocaine, the other five received sterile saline. All tests were then repeated. No statistically significant difference was observed in any measurement before and after injection in either test group. It is concluded that intraarticular anesthesia has no effect on gait pattern or joint proprioception as measured.

Intraarticular local anesthesia is used in sports medicine to alleviate pain during arthroscopy of the knee under local anesthetic. The possibility of permitting damage in the early postoperative period due to loss of joint position sense is addressed in this paper. The results of this study suggest that injection of local anesthetic into a joint with an intact joint capsule does not compromise joint position sense as measured in this study. Furthermore, no change in gait parameters was observed in the functional task of ambulation. It must be noted that no conclusions regarding the loss of pain sensation can be made from the results of this study. Also, no conclusions regarding competitive activity can be drawn from this study.

Awareness of position of the extremities depends on sensory input from peripheral receptors. Determining which recep-

tors are primarily responsible for proprioception is a point of some controversy. Traditionally, capsular receptors have been thought to be primarily responsible for this sensation.^{4,12,15,17} More recently, extraarticular receptors, particularly in muscle, have been assigned a dominant role.^{4,7,8,10} Previous experiments producing anesthesia in a joint have produced contradictory findings, some claiming little effect,^{3,7} others demonstrating significant decline in sensation.^{1,16} Evaluation of the effect of anesthesia in these experiments has generally consisted of subjects' response to passive change in position by the investigator. No test has been done to determine if intraarticular anesthesia causes a measurable change in a subject's performance of an automatic task such as walking.

Aside from the neurophysiological implications, the question of the effect of intraarticular anesthesia has clinical applications. It is increasingly common in many centers for athletes to undergo diagnostic knee arthroscopy under long-acting (bupivacaine) anesthetic.¹³ These anesthetics may cause partial or complete anesthesia for as long as 12 hours. Also, arthritic patients often undergo diagnostic or therapeutic arthrocentesis with instillation of medication and/or local anesthetic intraarticularly. Whether the function of these patients is compromised for a length of time warranting a period of protected weightbearing is a question which requires an answer.

Although gait is a highly automatic motion involving postural and locomotive reflexes, it does not involve the high stresses involved in competition with higher speeds and sudden rotatory forces particularly seen in contact sports. Therefore, conclusions from gait studies cannot be directly applied to the competitive arena.

To investigate the effect of intraarticular anesthesia and the possibility of functional changes which might predispose patients to injury, a study was first performed to reproduce previously documented tests of joint proprioception. Secondly, gait studies were performed as a physiologic test of practical function. Tests were performed before and after intraarticular anesthesia was administered in a double-blind manner.

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MATERIALS AND METHODS

Ten syringes were filled with 10 cc of either sterile saline (five) or 2% lidocaine (five) by an independent party who labeled the syringes and kept a code which was not broken until the conclusion of the experiment.

Ten volunteers (five males and five females, average age 28 years) with normal knees by history and by physical examination were selected. These volunteers were given informed consent and signed consent forms approved by the Human Studies Committee of our institution. All volunteers underwent gait studies using a Veterans Administration (VA) Rancho footswitch stride analyzer. Multiple runs were done and the average velocity, cadence, stride length, and gait cycle were determined. Force plate tracings were made of the left lower extremity before and after injection and included vertical, fore-aft, and mediolateral forces.

Also, videotape recordings of the gait of both lower extremities were made before and after injection. Markers were placed on the greater trochanter, knee, and ankle to permit knee motion measurement. Analysis was performed by photography of the video picture with frame-by-frame advancement of the gait cycle (1/30 sec/frame). These photographs were then measured with a goniometer to plot knee motion (angle of flexion) as a function of gait cycle for before and after injection for each subject. Gait cycle was taken as the time from heel strike to ipsilateral heel strike as observed on the video picture.

The volunteers then were evaluated for joint position sense by two methods using an apparatus that was designed to consistently position patients and to eliminate all external cues to limb motion except those emanating from the knee and surrounding tissue.

Subjects were seated, reclining to 60° to encourage relaxation and with legs hanging freely over the side of the seat at a distance of 4 to 6 cm proximal to the popliteal fossa. Custom-made Jobst air splints were fitted above and below the knee joint and inflated to 20 mm Hg to neutralize cutaneous sensation. The inflated thigh cuff was then immobilized in flexible orthoplast splints using Velcro straps to ensure the same starting position for each test repetition. Movement of the extremity was accomplished by means of

a wire attached to the tip of the leg air splint (Fig. 1). Subjects were blindfolded to remove visual input.

Reproduction of passive positioning

The patient's leg, which started in free hanging position of 90°, was pulled passively along the natural line of extension to a random angle of 5 to 25° from starting position. After concentrating on the position of the leg for 2 to 3 seconds, the patient was asked to return it to the same angle.

Angular displacement was approximated by a formula based on linear displacement of the leg and radius of curvature of the resulting arc delineated by the heel (Fig. 1).

After 10 repetitions (5 on each leg), a mean value of accuracy in reproduced movements was recorded.

Threshold to passive motion

Both leg air splints are suspended by wires attached to pulleys driven by a slow speed motor with a long shaft extending from it. The position of the pulleys on the shaft can be adjusted in order to pull the legs along their natural arc of extension. A starting position of 60° as measured by goniometer is used so that the pull of gravity is already applied to the wire. This serves to minimize any cues to the onset of motion. The motor is started with neither pulley engaged. The subject is given a control box with an on-off switch to press when he detects position change. He is informed that one of his legs will slowly change position at a random time from 5 to 30 seconds after the motor is started, serving to eliminate auditory cues. The shaft slowly moves at a precalibrated rate which will produce an angular deflection of 0.5°/sec once the pulley is engaged. The linear movement of the wire is measured in millimeters and converted to angular deflection as described previously. Ten repetitions were performed on each subject, 5 on each leg in a random sequence. A mean value is calculated for each leg separately and both combined. After completion of gait and position tests, the left knee of each volunteer was injected with 10 cc of sterile fluid in a double-blind manner. All tests were then repeated.

RESULTS

A tabulation of results of foot switch gait measurements and proprioception measurements is shown in Table 1 along with normals for our laboratory. No significant differences were seen between groups for the foot switch data, the force plate data, or the proprioception data.

An example of knee flexion of the left knee during gait before and after injection of lidocaine is shown in Figure 2. Motion was found to be essentially identical before and after injection for both the saline and lidocaine group. Since it could be postulated that a decrease in proprioception sense after injection could cause overshoot in knee flexion during swing phase gait or collapse during stance phase flexion, this aspect was investigated by measuring maximum knee flexion on each subject before and after injection. The average change in maximum knee flexion during swing phase for the

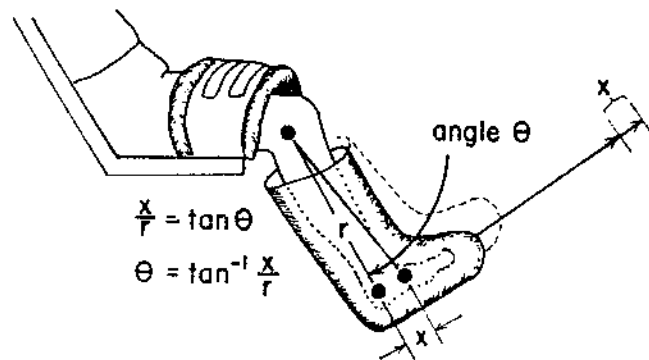


Figure 1. Schematic drawing of the experimental arrangement of the subject. Measurements of the distance "x" permit calculation of the angle of flexion for threshold measurements for reproduction measurements.

TABLE 1
Results of gait analysis and proprioception measurements^a

Subject/Sex	Velocity (m/min)		Cadence (steps/min)		Stride length (m)		Gait cycle (sec)		Proprioception				
	Before	After	Before	After	Before	After	Before	After	Reproduction (deg)		Threshold (deg)		
Lidocaine													
1. M	75.5	74.9	103.0	104.7	1.462	1.430	1.16	1.15	0.8	0.8	3.8	4.3	
2. F	80.2	76.6	117.3	114.5	1.370	1.338	1.03	1.06	3.5	3.0	5.8	5.0	
3. M	64.8	77.5	103.0	103.0	1.364	1.462	1.16	1.16	1.2	3.1	3.2	5.4	
4. F	71.7	77.6	113.0	120.5	1.269	1.290	1.06	1.00	2.0	2.5	3.7	4.3	
5. M	88.3	87.4	121.8	123.0	1.453	1.422	0.988	0.977	2.6	2.5	3.3	6.6	
Saline													
1. F	75.7	78.6	114	116	1.328	1.353	1.03	1.06	1.8	1.8	5.8	5.9	
2. M	81.3	78.2	111	107	1.451	1.458	1.07	1.12	0.9	1.0	5.6	5.1	
3. F	76.5	82.0	117	117	1.359	1.398	1.07	1.03	4.3	2.5	4.0	4.0	
4. M	74.6	79.8	109	110	1.367	1.445	1.10	1.09	1.7	0.7	4.8	4.8	
5. M	89.3	84.2	114	112	1.561	1.505	1.05	1.07	2.9	1.6	4.8	4.1	
Male normals (±SD)	77.3 ± 10.8		104.5 ± 9.0		1.469 ± 0.123		1.152 ± 0.130						
Female normals (±SD)	71.1 ± 7.3		114.9 ± 7.5		1.242 ± 0.113		1.047 ± 0.063						

^a All measurements are averages.

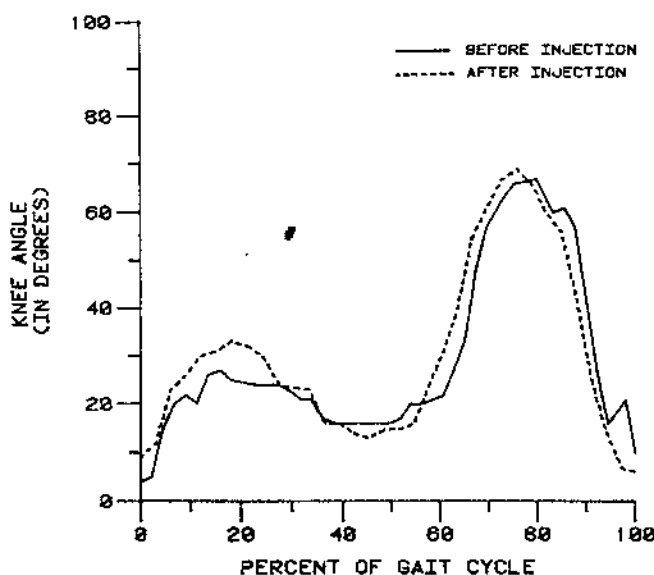


Figure 2. Knee flexion during gait before and after lidocaine injections. (Subject number 1.)

saline group was $2.8 \pm 8.1^\circ$ decrease compared to an increase of $1.2 \pm 4.8^\circ$ for the lidocaine group. During stance phase, the average difference in maximum knee flexion was 2.4 ± 5.3 (increase) for the saline group and -3.6 ± 12.6 (decrease) for the lidocaine group. Error limits are the SDs and no statistically significant difference was noted.

Figures 3 and 4 correlate proprioception measurements before and after injection with saline and lidocaine, respectively. It would be expected that a slope of 45° and an intercept of zero would be realized if there was no change. The saline measurements yielded a correlation coefficient of 0.932 ($P < 0.001$) with a slope of 0.869 and an intercept of 0.922. The lidocaine measurements yielded a correlation

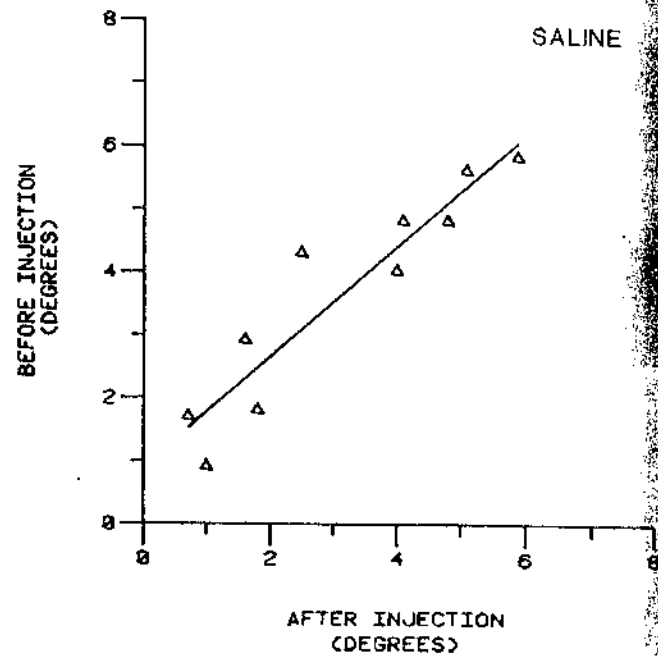


Figure 3. Plot of proprioception before and after injections of the knee with saline.

coefficient of 0.664 ($P < 0.05$) with a slope of only 0.563 and an intercept of 0.878. No significant difference was found between the slopes of lidocaine and saline measurements. Thus, the introduction of fluid into the knee joint probably accounts for the variation of the slope from unity rather than an effect from anesthetic.

DISCUSSION

Proprioception measurements for normal young subjects correlated well with findings of previous investigators using

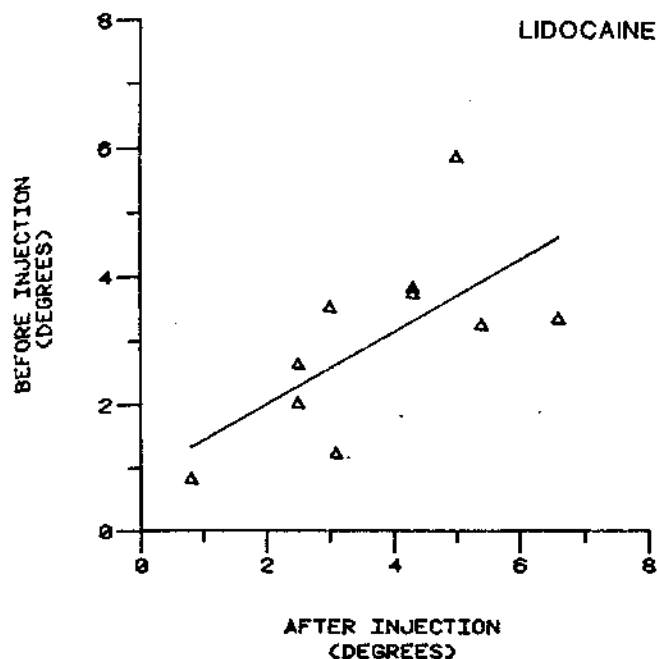


Figure 4. Plot of proprioception before and after injection of the knee with lidocaine.

a similar experimental design.^{2,3} No difference was seen in proprioception measurements before and after injection, a finding also previously reported.³

Aside from sensing position, capsular receptors are also thought by many to originate reflexes important in posture and locomotion.^{5,9,15} In addition, recent studies have claimed that knee capsular receptors respond only near extremes of joint motion or when the joint is in compression.^{9,11} Neither of these conditions are met during the tests commonly used to measure proprioception. In order to evaluate postural and locomotive reflexes originating in the capsule and to test the joint in compression, gait studies using motion analysis, force plate analysis, and the stride analyzer were done. It is reasonable to think that intraarticular anesthesia blocks the capsular receptors since recent studies have localized these receptors on the innermost portion of the capsule. In addition, after local anesthetic was placed in the joints of experimental animals, changes in articular nerve potentials have been directly measured, strongly implying successful anesthesia of joint receptors.³

In spite of the assumed anesthesia of capsular receptors, no change was seen in any gait parameter or in joint proprioception as measured. Correlation of proprioception studies before and after injection with both fluids suggested a slight effect from the increase in fluid in the joint. If, in fact, important postural and locomotive receptors originate in the

capsule,⁵ then full compensation must occur in their absence. No functional deficit in ambulation could be documented after intracapsular anesthesia of the knee joint.

Based on these results, it does not appear that limitation of normal weightbearing is necessary immediately following diagnostic or therapeutic arthrocentesis and anesthetic injection in patients or athletes being treated. Furthermore, it seems unlikely that athletes undergoing diagnostic arthroscopy under local anesthetic for evaluation of an injury are in a compromised condition with regard to immediate return to activity. However, it would seem to be prudent to discourage any activity other than simple ambulation after such procedures until anesthesia had worn off.

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