A NEW TREATMENT METHOD OF QUADRICEPS MUSCLE INSUFFICIENCY: USING DYNAMIC INTERNAL SPLINT: An experimental study: Preliminary report

Kuadriseps adelesi yetersizliğinde yeni bir metod: Dinamik iç destek kullanımı

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Summary: *We produced quadriceps muscle paralyses experimentally in dogs by sectioning the femoral nerve at the inguinal ligament level. The impaired extention mechanism of the knee was reinforced by a Dynamic Internal Splint placed in the quadriceps muscle mass and attached proximally to the ilium and distally to the patella by wire sutures. The gait type and the elasticity of the Internal Splint were tested and recorded postoperatively. Biopses of the surrounding soft tissues and the iliac bone were taken for histological examination.*

Key Words: *Muscular paralysis quadriceps*

Özet: *Köpeklerde inguinal ligament seviyesinde femoral siniri keserek deneysel kuadriseps adelesi felci oluşturuldu. Yetersiz duruma gelen diz ekstansiyon mekanizması proksimalde ilium'a distalde patella'ya tel dikişlerle tutturulan Dinamik İç Destek'le kuvvetlendirilmişdi. Postoperatif olarak yürüme şekli ve iç desteğin elstisitesi test edildi ve kaydedildi. Histolojik inceleme için çevre yumuşak doku ve iliak kemikten biyopsi alındı.*

Anahtar Kelimeler: *Kuadriseps adelesi felci*

The quadriceps femoris muscle is the principal knee extensor. Its izometric contruction locks the knee joint and acts as knee stabilizer. Quadriceps muscle strength is essantial for climbing stairs and for estabilishing stability of the knee (7).The insufficency of this muscle is usually neurogenic. Disability from paralysis of the quadriceps muscle is severe. The knee may be exceedingly unstable, especially if there is the slightest fixed flexion contracture (4). When instability of the knee is due to quadriceps paralysis after poliomyelitis it prevents free movement. Usually two methods of treatment are performed today; first, by using external supports (Orthotic devices and braces); second, by muscle transfers (Hamistrings). Biceps femoris, semitendinosus, sartorius, tensor fascia lata and adductor longus are the muscles transfered to reinforce the paralyzed quadriceps muscle (4-6,8-10). If there is any flexion contracture of the knee joint , genu recurvatum , genu valgum, equinus deformity of the ankle or ticeps surae contracture, these must be corrected before any muscle transfers are made (3,5,6).

In this experimental study we used the Dynamic Internal Splints on dogs with paralysis of the quadriceps muscle .

METHODS

Two adult male dogs (10 and 12 Kg) were used in this study.

The technical preparation of the Dynamic Internal Splint: The distance between the superior anterior iliac spine and the patella were measured bilaterally before operation on two dogs. Two synthetic vein grafts having bellows (Collagen Coated Knitted Dacron® Vascular Prosthesis-HEMAGUARD-K) were prepared equal in length but different in diametre. The diametre of the larger one was 14 mm, and the smaller one was 10 mm, and 8 mm elastic tube in diametre which was 1 mm shorter than the grafts was prepared. At first, the 10 mm diametre vein graft was put on the elastic tube and both ends of this tube was covered by the graft material and sutured in place with 3.0

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steel sutures. The ends of the sutures were cut long and left free. Later, the vein graft larger in diametre (14 mm) was put on the first graft to complete the Dinamic Internal Splint that we were going to use (Figures 1 and 2)

Operation and application of the Dynamic Internal Splint: Under general anesthesia, with the dog supine, the area from the lower half of the abdomen to the knee joint was prepared by Betadine® (% 10 povidone-iodine poly (1-vinyl-2-pyrolidon)-iod-complex). Starting just distal to the anterior superior iliac spine a longitudinal insizyon (Iliofemoral) was made, and extended distally to expose the anterior margin of the iliac bone, the origin of the rectus femoris muscle and medially the femoral arter, vein and nerve under the Poupart ligament. After determinating of the femoral nerve by electrical stimulation, a segment (0.5 cm) was resected from the femoral nerve at the level before innervating the quadriceps muscle. From the proximal end of the rectus femoris muscle, a segment (0.5 cm) was cut and let the muscle free. The Dynamic Internal Splint was fixed to a small hole made on the iliac bone 0.5 cm posterior to the anterior inferior iliac spine. This fixation was done by wire sutures which were at the proximal end of the internal sheath of the splint (Internal vein graft). The proximal end of the external sheath (external vein graft) was attached to the surrounding soft tissue by PDS (Polydioxanone suture) sutures. Then the quadriceps femoris muscle was split longitudinally, and after careful heamostasis, the Dynamic Internal Splint was placed under this muscle and over the periost of the femur. The patella was exposed by medial parapatellar incision. With the wires at the distal end of the internal sheath, the splint was firmly fixed to the patella with the knee at 20-25 degrees of flexion. After dividing the quadriceps tendon from patella, the distal end of the external sheath of the splint was sutured to the surrounding soft tissue. The knee was immobilized at 20-25 degrees of flexion by an external fixation device with one kirschner wire in the femur and another in the tibia (Figure 3). The longitudinal splitting of the quadriceps muscle was deeply sutured, the subcutaneus tissue and the skin were sutured in a normal manner. The same procedures were applied on the opposite hind limb. 1 gr (Im) Sefalosporin was profilactically administred one hour before the operation, and 1 gr per day during 10 day of postoperative period. Three weeks later, the external fixation devices were removed and the dogs permitted to walk. Photographs of their gaits were taken, and the type of the gaits were recorded by a video camera, and active motion of the knee joint measured with a goniometre . Alteration or progression of these conditions (active motion of the knee and gait) was recorded routinly every day. Eight weeks later the passive range of the motion of the knee joint and the resistance of the Dynamic Internal Splint were tested by Tensometre (500-Monsanto, 471-1984-England). Under general anesthesia, the Dynamic Internal Splints were removed from both hind limbs of one dog three months after the operation and six months later from the other dog. During this operation, the area where the splints were removed from was inspected macroscopically for evidence of reaction or infection. The biopsies were taken for histological examination from surrounding tissues and from tissues at the proximal and distal end of the wound including that part of the ilium where a hole was made for the proximal fixation of the splint.

RESULTS

After the operation no infection was found and the wounds healed in 7 - 10 days. When dogs were freed their motions were inspected and their progress recorded every day. We observed that both dogs held their knee joints at 20-25 degrees of flexion while resting. Transition from sitting position to walking position became near normal after five weeks postoperativly (Figure 4 and 5). During walking, the range of active motion at knee joints measured by goniometer was about 60 degrees. Passive hyperflexion of the knee joints was painful. When we produced pain by introducing a needle into the front of the legs, we saw that the knee joints flexed actively about 15-20 degrees more.

Eight weeks after the operation under general anesthesia, with the hip joints at neutral extention, the knee joints were forced to maximum flexion by a tensometer (500 - Monsanto). Under 50 mm / Sec. pressure and speed with an average 58 Newton force we obtained an average of 120 degrees of passive flexion at the knee joints, and there was no loosening at the Dynamic İnternal Splints in both dogs.

Three months after the operation, the Dynamic İnternal Splints were removed from both limbs of one dog and six months later from the other dog (Figure 6). One week after the removal of the splints, when the wounds healed, the dogs let free to move. We noted that both dogs could not stand up on their hind limbs, and that they walked only by using their fore limbs (Figure 7). As a result of quadriceps paralysis there was no active extention at the knee joints. All these findings were recorded on still and video film.

During the removal of the Dynamic İnternal Splint, we didn't see any sign of infection in the operation field. However some granülation tissues were seen near the proximal and distal end of the splint. The culture specimen taken from the operation area was negative.

During operations, when the splint were removed, there were some adhesions of the quadriceps muscle to the body of the Dynamic İnternal Splint. Study of the biopsies, taken from the soft tissues both surrounding the body and the proximal and distal end of the splint, displayed only a little lenphocyte infiltration. Histologically there was no other patological findings on the examined biopsies.

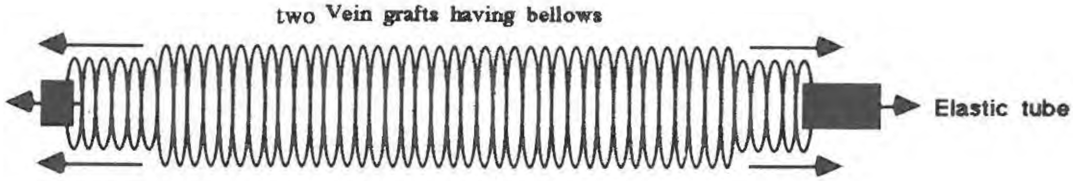

Figure 1. Diagram of the dynamic internal splint

Figure 2. The dynamic internal splint is ready to use

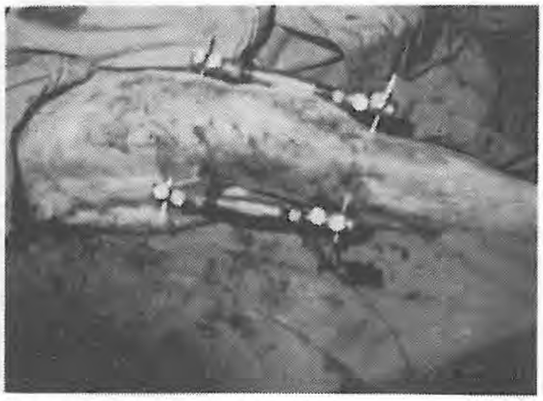

Figure 3. After the operation the knee was immobilized by external fixation

Figure 4. Six weeks after operation, the dog during walking

Figure 5. Six weeks after operation, enteresting position of the dog during urination

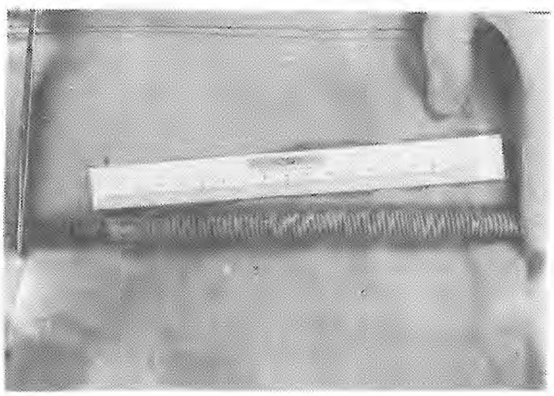

Figure 6. The splint after removal. The splint keeps its elasticity after six months

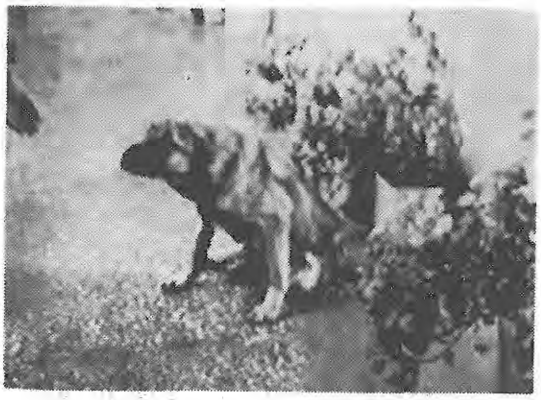

Figure 7. After removal of the splint the dog cannot stand on its hind limbs

DISCUSSION

From 1897 until today, various tendon transfers were prescribed for paralysis of muscles around the knee joint (1). Kleinberg in 1957 reported the complete transplantation of the adductor longus muscle including its neurovascular pedicle to supplement the quadriceps in one patient (4). Hemistring transfers for paralysis of quadriceps are advised when the patients dispanse from their orthoses (8). It is really a great problem for patients to wear and to take off heavy and coarse metals. Consequently, tendon transfers has become a savior method for such patients. On the other hand, this procedure has some disadvantages and complications which should be considered. When a strong muscle is transferred to reinforce a paralized muscle, the former muscle will lose its function, and this function may be replaced only partially or inadequately by the sinergic muscle or muscles. Classically, it is known that the transferred muscle will lose one degree of its strength (4,8). The patient's cooperation is very important in evaluation of muscle strength, planning of tendon transfer, and postoperative rehabilitation period (5,6). Careful rehabilitation programs must be continued for a long time after tendon transfer operations. Otherwise bad results are inevitable (4,6,8,9). The complications of tendon transfers are ; genu recurvatum, dislocation of patella, lateral instability of the knee joint , and denervation possibility of a muscle at operation (1,3,4,6,8,9). We think that our method will reduce these disadvantages and complications. It is obvious that our method has two very important advantages as compared to the previous methods. First, the function of paralized muscle will be carried out by Dynamic Internal Splint. Second, there is no use and no damage of any functioning muscle.

The materials used in preparation of the Dynamic Internal Splint are flexible in their quality and quantity. For example common elastic tube (after sterilization) was used in our study, but to minimize the tissue reaction the tube was placed inside the two synthetic vein grafts having bellows. After three and six months of follow up, during postoperative period no reaction was seen in either cases. However, this does not mean that any reaction will never occur. We think that an elastic tube may be designed specially for this purpose or a spring made from steel may be useful to prevent such material reactions. Also a ring made from steel may be used to prevent erosion on the iliac bone at the margin of the hole made for the proximal fixation of the splint.

In this study, knee joint stabilitiy and locking in extention were obtained by this splint. At the swing phase of the gait, when the knee joint is actively flexed by the knee flexors, the elongation of the splint was proportional to the pulling force of the knee flexors. At the end of the swing fase when the knee flexors relaxed, the knee joint extended mechanically with the return of the Dynamic Internal Splint to its normal length. Repetition of these movements at the knee joint produced almost a normal gait.

In conclusion, this experimental study has been going on. However, the results obtained up to now, indicate us that if better quality materials are used and developed in the preparation of this splint, it might be used on patient having muscle paralysis.

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