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Healing of the cartilage and the subchondral bone tissue after trochleoplasty in dogs

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ABSTRACT

Trochleoplasty or sulcoplasty has always played a prominent role in the radical methods of sanation of patellar dislocation. The results of 20 operated dogs were considered. Two groups of experimental animals were operated on, one by rescission trochleoplasty and the second by abrasive trochleoplasty. Clinical, radiological, pathomorphological and histological findings were studied. Although rescission trochleoplasty produces a physiologically closer result to the preoperative cartilage, abrasive trochleoplasty is a much simpler technique to perform and is biomechanically a more efficient method in conceiving the stability of the stifle joint in the radical treatment of patella ectopy.

Key words: patellar ectopy, trochleoplasty, cartilage metaplasia, dog

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Introduction

At the beginning of the last century patellar luxation was cured only by conservative methods such as bandaging or scrubbing of the lotion (LIVESEY, 1913), contra-irritation (LACROIX, 1930; McLEAN, 1962) or manual reduction (GABRIEL, 1932). Although various investigations of the influence of the conservative treatment of the osteoarthrotic diseases of dogs and cats were published, as was the application of the estriol-testosterone combination (OETEL et al., 1974), modern treatment no longer recognises conservative methods, some authors even considering them inadequate on the basis of their own experience (GEYER, 1967; ROY et al., 1992). The choice of the radical method for sanation of the ectopic patella depends on an estimation of the changes that resulted in the dislocation. Methods that treat only the soft tissues are recommended in cases of intermittent luxation of the patella (primary the medial luxation) where the relations in the stifle joint are normal or only slightly changed, which means that the tuberositas tibiae extends along an imaginary line which follows the dorsal aspect of the m. quadriceps femoris, and ends on the dorsal axis of the downleg (FLO and BRINKER, 1979). Those techniques that impact on soft tissues such as the fascia lata overlap (FLO and BRINKER, 1979) or quadricepsplasty (MADIGAN et al., 1975) are not considered as being permanent corrections and are applied only as added support to methods such as the transposition of the caput fibularis with deepening of the trochlear groove (SLATER, 1994).

Recent investigations show that the most important of the various techniques is the transposition of the tybial crest, together with trochleoplasty and antirotational techniques. Experimental investigations showed that the defect after trochleoplasty was corrected with well vascularized distracted connective, tissue which in time changes metaplastically into dense connective tissue, and finally into fibrous cartilage (MOORE and BANKS, 1989). It was assessed that the hyaline cartilage defect did not regenerate in the process of sanation but were repaired by the fibrous cartilage, mostly by the connective tissue cicatrix which functionally satisfies the motoric capability of the operated joint (KOS et al., 1990).

Materials and methods

Animals. Research was performed on 20 clinically healthy dogs of mixed breeds (in the German Shepherd phenotype) and of ages varying from 8 to 24 months. The dogs were from the breeding facilities of the Clinic for Surgery, Ophthalmology and Orthopaedics, Veterinary Faculty University of Zagreb, Croatia, and were divided into two groups of 10 dogs: group A – comprising the dogs on which abrasive trochleoplasty was performed, and group B - comprising the dogs on which resectional trochleoplasty was performed.

All procedures on the dogs during the experiment were conducted according the European document regarding the keeping and handling of laboratory animals (86/609/EEC) (VAN ZUPEN et al., 1993).

Fig. 1. Defect in the trochlear groove after removing articular cartilage and subchondral bone after abrasive trochleoplasty

Surgical technique. The experimental dogs were prepared for the operation in the usual manner. Pre-medication was achieved by i/m application (the dorsal aspect of the m. quadriceps femoris) of a combination of atropine sulphate (0.05 mg/kg) (Pliva, Croatia) and

Fig. 2. Smoothing of the groove with rasp

acepromazine (0.1 ml/kg) (Sedalina, Chassot, Switzerland). Ten to fifteen minutes after sedation appeared, ketamine chloride (15 mg/kg) (Narketan, Chassot, Switzerland) was applied.

Fig. 3. Separating the cartilage and part of the subchondral bone with straight chisel after resectional trochleoplasty

Fig. 4. Deepening the intercondylar groove by curette

In the both experimental groups the lateral approach to the stifle joint was performed in order to achieve better exposition of the femoral trochlea (PIERMATTEI and GREELEY, 1979).

The trochleoplasty technique. In group A the articular cartilage (to a depth of 1-2 mm) and the subchondral bone were removed using a grooved chisel (Fig. 1) and the edges and the surface of the defect were smoothed by a fine bone rasp (Fig. 2). The defect was flushed with physiological solution.

In group B the cartilage of the trochlear groove was first cut parallel with the femoral condyles and on the proximal aspect of the trochlea, then cautionally separated from the small part of the subchondral bone of the femur with a straight chisel (Fig. 3). The inter-condylar groove was then deepened with a curette (Fig. 4). After reaching the required depth the flap of the articular cartilage was replaced in its position. The deepened groove was flushed with Ringer's solution.

In the both groups the patella was relocated, the extremity was positioned in full extension and the articular capsule and lateral retinaculum were reconstructed by Reverdin suture pattern using Dexon 3-0 (Ethicon,

USA). Subcutaneous fascia, subcutis and skin were reconstructed using the near-far-far-near suture pattern with Vycril 2-0 (Ethicon, USA). The dogs were treated with antibiotics (0.1 ml/kg) (Sustrepen, Pliva, Croatia) within 6 post-operative days.

Radiological and clinical examination. All experimental dogs were radiologically examined on the 1st day following the operation and were clinically observed every day from the operation until the 60th post-operative day.

Pathomorphological examination. The animals were sacrificed on 60th post-operative day. The dogs were euthanatized by i/v application of T-61 (0.3 ml/kg) (Hoechst Roussel Vet., Germany). The pathomorphological examination was carried out in the usual manner.

Histological examination. Specimens of treated trochlear tissue were taken from the operated knees of dogs in both groups. The specimens were approximately 1 cm wide and 2 cm long. They were fixated with 10% formaldehyde (Kemika, Croatia), decalcified by 20% formic acid (Kemika, Croatia), then inserted in low polymeric paraffin (Kemika, Zagreb), and cut using a microtome into slices 5-7 micrometers in width and placed on microscopic slides covered with collides. They were coloured by Gill hematoxilin eosin (GILL et al., 1974).

Results

Clinical findings. At 24 hours after the operation swelling in the operational zone (the lateral side of the distal third of the femur and proximal quarter of the tibial region) was observed. Within the next 48 hours the patients did not use the treated leg, while 4 days after the operation they began to burden the operated leg slightly, exhibiting 2nd grade lameness (Fig. 5). Lameness was not observed in

Fig. 5. Patient burdening the operated leg 4th day after the operation

Fig. 6. X-ray photography of the operated stifle joint of group A

Fig. 7. X-ray photography of the operated stifle joint of group B

the normal gait until the 7th day after the operation, but only when the patient was led in the circles with the operated extremity on the inner side. Between the 10th and 14th days no lameness was observed.

Radiological findings. On the anterioposterial projection of the stifle joint after trochleoplasty was performed, with the loss of the articular cartilage and part of the subchondral bone (group A), sharply outlined articular edges could be observed with appropriate articular fissure and patella posted physiologically. The intercondylar groove was approximately 8 mm wide and 7 mm deep (Fig. 6).

On the anterioposterial projection of the stifle joint after trochleoplasty, without loss of the articular cartilage (group B), the articular edges and

fissure are neat and sharply outlined. Rarefaction of the bone from the distal edge of the patella up to the articular fissure could be clearly observed (Fig. 7).

Pathomorphological findings. On the post of the operational cut, slightly developed mature cicatrical tissue could be observed. An insignificant quantity of mature connective tissue was present in the

Fig. 8. Trochlear groove of sacrificed patient 60 days after abrasive trochleoplasty

subcutis, while on the articular capsule and cartilage surfaces of the patella no pathological changes could be observed. In group A the intercondylar groove is slightly recessed and covered with fibrous cartilage (Fig. 8).

In group B, on the site of trochleoplasty a slight quantity of mature connective tissue was present. The articular surfaces of the condyles and the patella were without visible changes.

Histological findings. On the marginal zone of the abrasive trochleoplasty (group A) the hyaline cartilage was replaced with connective tissue which corrected the defect and followed the border of the articular surface (Fig. 9). The bearing edge of the defect was not entirely smooth but covered with a dense layer of cells. Above the surface layer of the

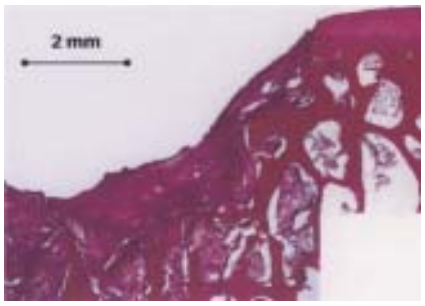

Fig. 9. Marginal zone of defect, made by abrasive trochleoplasty. H&E; ×10; scale bar = 2 mm

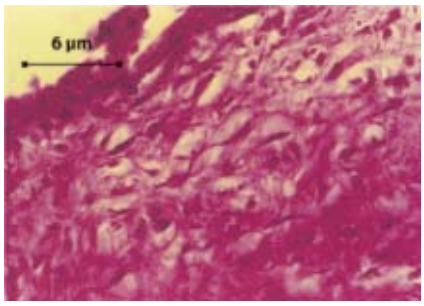

Fig. 10. "Chondrocites resembling cells" on the button of the defect made by abrasive trochleoplasty. H&E; ×150; scale bar = 6 µm

cells, compensatory connective tissue was disposed in a superficial thinner layer and a deep thicker layer. The thinner layer was composed of irregularly positioned connective fibres and numerous fibroblasts, with an increased nucleus of visible edge hypercromatism. The deeper layer was built of parallel sheaves of collagen fibres which follow the articular surface, with fibroblasts included between the sheaves. In some spots of the

Fig. 11. Juncture of the hyaline cartilage that had grown together after resectional trochleoplasty. H&E; ×31.2; scale bar = 290 µm

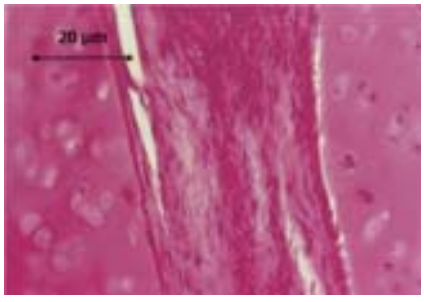

Fig. 12. Layer of connective tissue between the original hyaline cartilage and the cartilage that had grown together after resectional trochleoplasty. H&E; ×100; scale bar = 20 µm

compensatory tissue, groups of chondrocites resembling cells were observed (Fig. 10). Also, good vasularisation stemming from the subchondral tissue was observed, especially in the deeper layers.

The defect obtained by resectional trochleoplasty in dogs from group B was properly healed, without any presence of inflammatory cells. On the juncture of the hyaline cartilage and the cartilage that had grown together, a layer of thick connective tissue that had grown into the subchondral bone was observed (Fig. 11). The connective tissue was built from the sheaves of ungular collagenous fibres with fibroblasts flowing from the articular surface to the subchondral bone (Fig. 12). The area of collagenous fibres that filled the space between the cartilage that had grown together and the bone bars of the subchondral bone was well vascularised.

Discussion

The recent investigations of trochleoplasty mostly observe the sanation process within 2 to 40 weeks of investigation after the operation was performed. Two basic problems were investigated. First, whether intrinsic or extrinsic factors were more essential to the healing process; the second, which tissue was the final result of the healing process. As the fibrous connective tissue which corrected the defect in the earlier phases of the healing changed into fibrous cartilage, the presence of chondroblasts was anticipated (MANKIN and LIPIELLO, 1971). The chondrocites in the injured cartilage divided, forming chondromes and synthesised glycosaminoglycanes (GAG), and protein after the 1st week of the healing process (DEPALMA et al., 1966; MANKIN, 1974). The inner healing by replication of chondrocytes could hardly stimulate the complete healing of the injured cartilage, except in the immediate postnatal period (MANKIN, 1974; STOCKWELL, 1979; GARDNER, 1980; GHADIALLY, 1983). In the research carried out 16 weeks after the operation, interruption of the hyaline cartilage was observed in the trochleoplasty groove, and the repairing connective tissue failed to be covered by the hyaline cartilage (JAYMA and BANKS, 1989). It was clear that the full thickness articular cartilage defects that penetrated the subchondral bone possessed other sources of reparatory cells apart from chondrocites. The mezenhimal cells of the subchondral bones, the

subchondral circulation, the peripheral synovial membrane, and even synovial liquid, contribute to the healing process (STOCKWELL, 1979). Therefore, most authors estimate that the operation lesion should reach the subchondral bone to accomplish healing (KOS et al., 1990; MINAS and NEHRER, 1997) and that extrinsic factors have a greater influence on the reparation process. Despite the fact that some authors estimate that canine articular cartilage possesses a potential for spontaneous regeneration (WANG et al., 2000), the fibrous cartilage has been described by others as a substitute tissue for a deep articular defect (RIDDLE, 1970; MANKIN, 1974). Although it could not present compression and abrasion as hyaline cartilage (ZASLOW, 1972) it could be built by continuous movement of the patella and achieve an almost normal articular surface (VIERHELLER, 1967; VAUGHAN and ROBINS, 1975). Although in our investigations the final result of the reparatory process was not assessed, it was obvious that development of reparation led to a fibrous cartilage. The results of our experiment mostly concur with descriptions by other authors. However, other authors experienced 2 weeks of post-operational recovery (JAYMA and BANKS, 1989), and our experimental dog were using the treated extremity on the 4th day after the operation. Within 10 days of the operation there were no signs of lameness. Clinical findings were similar in groups A and B. Radiological findings were also in concurrence with observations described by other authors 24 hours after the operation. Considering that the authors assessed that no radiological findings were visible, despite the deepened trochlear groove 16 weeks after the treatment (JAYMA and BANKS, 1989) we did not find it necessary to make an x-ray examination 8 weeks after the operation. Pathomorphological findings revealed neat healing of all tissues in the operated knee. This may be result of lesser irritation caused by the sutures, since we reconstructed the knee in two stages only. Histological findings from group A showed the forming of thick connective tissue on the site of the trochleoplasty. Connective tissue was distributed in the superficial thinner layer and the deep thicker layer, with parallel sheaves of the collagenous fibres following the articular surface. Fibroblasts and the chondrocites resembling cells were included in the connective tissue. This clearly indicated metaplasia of the substitution connective tissue into the fibrous cartilage. In group B the very regular healing of resected cartilage

by dense connective tissue was observed. Although we performed modified trochleoplasty (the incision on the articular cartilage was made as for the performance of cartilage flap sulcoplasty, although the subchondral bone was gripped as for "V" trochleoplasty), ideal healing of the autotransplant was obtained because of the subchondral vascularisation of the juncture with the original hyaline cartilage. Although some authors describe the advantages of resectional trochleoplasty (SLATER, 1994), others assess that this method is applicable exclusively to younger dogs and is rather complicated to perform on small and toy breeds (HULSE, 1986) which most commonly suffer from patellar dislocation. Our findings show that the performance of both methods equally preserve the functional capability of the operated limb. Abrasive trochleoplasty is a technically less demanding method and is a widely applicable technique, especially for small patients as well as the very young, when the results of the treatment are best.

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BABIĆ, T., J. KOS, A. BABIĆ, M. BUDEČ, D. STANIN, S. VUKOVIĆ, M. POPOVIĆ: Zaraštanje hrskavice i subhondralnog koštanog tkiva nakon trohleoplastike u psa. Vet. arhiv 71, 173-186, 2001.

SAŽETAK

Među metodama radikalne sanacije dislokacije patele, trohleoplastika je uvijek zauzimala istaknuto mjesto. U obzir su uzeti rezultati 20 operiranih pasa. Operirane su dvije skupine eksperimentalnih pasa: skupina A abrazijskom trohleoplastikom, a skupina B resekcijskom. Proučeni su klinički, radiološki, patomorfološki i histološki nalazi. Iako resekcijska trohleoplastika daje rezultat bliži preoperativnoj zglobnoj hrskavici, abrazijska trohleoplastika je znatno jednostavnija metoda, a biomehanički zadovoljava stabilnošću koljena nakon radikalne sanacije ektopije patele.

Ključne riječi: ektopija patele, trohleoplastika, hrskavična metaplazija, pas