

Effects of triple pelvic osteotomy on anatomic structures of the pelvic region in the dog

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Summary

Triple pelvic osteotomy has been used in dogs to maintain normal form and anatomical function of the hip in canine hip dysplasia. Pelvis subjected to triple pelvic osteotomy undergo several architectural changes of different magnitudes. The aim of this study was to determine the positional changes of the anatomical structure of the pelvis after unilateral triple pelvic osteotomy in five mongrel dogs. Atrophy of the middle gluteal muscle, reduction in tension of the external and internal obturator muscles, compression on the caudal gluteal vein and entrapment of the sciatic nerve at the level of the ilial body were the most remarkable findings in the study. From an anatomical standpoint, it is suggested that the lateral rotation of the acetabulum should be kept minimal to guarantee least alterations in the normal anatomic architecture of the pelvic region.

Keywords: anatomy, triple pelvic osteotomy complication, dog.

Auswirkungen der Becken-Dreifachosteotomie auf anatomische Strukturen im Beckenbereich beim Hund

Die Becken-Dreifachosteotomie wird bei Hunden mit Hüftgelenkdysplasie angewendet, um Form und anatomische Funktion des Hüftgelenks zu verbessern. Diese Operation führt zusätzlich zu unterschiedlichen Veränderungen im Beckenbereich. Die vorliegende Studie hatte zum Ziel, die anatomischen Veränderungen nach einseitiger Becken-Dreifachosteotomie bei fünf Mischlingshunden genauer zu untersuchen. Die auffälligsten Abweichungen bei den operierten Hunden waren eine Atrophie des M. gluteus medius, ein Spannungsverlust des M. obturator externus und internus, eine Kompression der caudalen Glutealvene sowie des N. ischiadicus auf Höhe des Iliumkörpers. Unter Berücksichtigung dieser Gesichtspunkte wird empfohlen, die laterale Rotation des Acetabulums möglichst gering zu halten, um so die anatomischen Veränderungen der normalen Beckenstruktur zu minimalisieren.

Schlüsselwörter: Anatomie, Becken-Dreifachosteotomie, Komplikationen, Hund

Introduction

Canine hip dysplasia is an inherited, developmental orthopaedic disease of the hip joint in dogs (Puerto et al., 1999). The earliest clinical sign of the disease is the laxity of the hip joint. This laxity causes incongruity of the joint biomechanics and triggers a series of events that retard normal development of the femoral head and acetabulum. The changes that occur seem to correlate with the degree and length of time of the biomechanical imbalance. If the imbalance is corrected before a certain stage in the development of the hip, the joint function returns to normal (Riser, 1975). For this reason, the triple pelvic osteotomy (DeHaan et al., 1993; Hulse and Johnson, 1997; Moses, 2000) and juvenile pubic symphysiodesis (Patricelli et al., 2002) have been used in young dogs to maintain normal form and function of the hip joint in canine hip dysplasia. Therefore, young dogs with radiographic

evidence of hip dysplasia without osteoarthritis and a normal dorsal acetabular rim are good candidates for triple pelvic osteotomy (DeHaan et al., 1993; Black, 2000). In this procedure, the acetabulum is laterally rotated after the ilial, pubic and ischial osteotomies. Pelvis subjected to triple pelvic osteotomy undergo several architectural changes of different magnitudes (Graehler et al., 1994), not only on the bone architecture but also on the position of other anatomical structures. For that reason, biomechanical evaluation (McLaughlin et al., 1991; Heyman et al., 1993; Poy et al., 2000) and postoperative complications (Simmons et al., 2001) after triple pelvic osteotomy have also been studied. The most common complications reported are pelvic canal narrowing and loss of screw fixation (Graehler et al., 1994; Johnson et al., 1998; Renberg et al., 2000; Simmons et al., 2001;

Borostyankoi et al., 2003; Altunatmaz et al., 2003). In addition, damage of the sciatic and cranial gluteal nerves as well as the obturator artery are also known to occur (Schrader, 1986; Graehler et al., 1994; Simmons et al., 2001; Borostyankoi et al., 2003; Altunatmaz et al., 2003). Most of the aforementioned complications do not always cause a functional deficiency and are generally accepted as minor and transient complications (Borostyankoi et al., 2003; Altunatmaz et al., 2003). Satisfactory results after triple pelvic osteotomy are reported to range between 93% (Schrader, 1986) and 86.2% (Johnson et al., 1998). Major complications after the surgical procedure seem to be very low considering the anatomic complexity of the region. This study was focused on changes of the anatomical structures of the pelvis after triple pelvic osteotomy emphasizing some advantages for the surgeons.

Animals, Material and Methods

This study was undertaken in five mongrel dogs (4 females and 1 male) which were about 10 months old and weighed around 13 kg at the time of operation. Ventrodorsal pelvic radiographs were obtained to measure the Norberg angle both before the operation and before euthanasia of each dog (Tab. 1). The more affected hip of a dog according to Norberg angles was chosen for the triple pelvic osteotomy. Following premedication with 0.02 mg/kg atropine sulphate, the dogs were anaesthetized by intramuscular administration of 1–2 mg/kg xylazine hydrochloride and 2 mg/kg ketamine hydrochloride. Then, the dog was placed in lateral recumbency with the leg to be treated upwards. For the pubic osteotomy, the treated leg was held at a position of 90° abduction and a 4–5 cm skin incision was made, starting from the pubis on the inside of the leg between pectineus and gracilis muscles, perpendicular to the median line. The origin of the pectineus muscle was isolated and severed from the iliopectinal eminence. After the soft tissue was carefully separated, the pubis was cut and a 1–2 cm long piece of bone was removed from the pubic ramus. For the

ischial osteotomy a 4–6 cm long skin incision was made parallel to the tuber ischiadicum from the lateral aspect to the starting point of the arcus ischiadicum. A part of the internal obturator muscle connection to the tuber ischiadicum was elevated and the obturator foramen was reached. After sufficient space was achieved, an osteotomy was done on the ischial table from the outside to the inside, parallel to the longitudinal axis of the pelvis. In the last step, for the ilial osteotomy and placement of the Canine Osteotomy Plate, a 10–15 cm skin incision was made between the ilial wing and the greater trochanter. Subcutaneous adipose tissue and gluteal fascia were dissected; the middle and the deep gluteal muscles were elevated. The body of the ilium was revealed. An ilial osteotomy was carried out immediately caudal of the sacroiliac joint, protecting the cranial gluteal nerve. After osteotomy, canine pelvic osteotomy plates with an angle of 20° were placed, and the line of osteotomy was fixed using cerclage wire (Slocum and Slocum, 1992). The operated areas were surgically closed. All cases were given 25 mg/kg cefazoline sodium and 4 mg/kg carprofen for 5–7 days after the operation and skin sutures were removed 8–10 days later.

After one year, the dogs were again anaesthetized and placed in dorsal recumbency. The abdominal cavity was opened mid-ventrally and the aorta and caudal vena cava were cannulated for flushing and injecting red and bleu latex. All specimens were kept at +4° C during the study and gross differences of the anatomic structures between treated and untreated sides recorded.

Results

At the time of euthanasia, the mean Norberg angle was 126° ± 5.5 at the treated side and the differences between the treated and untreated sides varied from 18° to 25° (Tab. 1), with a mean of 22.6°.

The first noticeable changes were atrophy of the cranial portion of the middle gluteal and pectineus muscles (Fig. 1). The appearances of the external and in-

Table 1. Characteristics and the Norberg angles of all treated dogs. (The operated side is shown in bold).

No	Age (month)	Sex	Weight (kg)	Norberg angle (degree)				Difference between two sides at euthanasia
				at operation		at euthanasia		
				right	left	right	left	
1	12	Female	14	96	100	120	100	20
2	12	Male	13	102	100	102	120	18
3	10	Female	14	100	105	130	105	25
4	10	Female	16	98	105	130	105	25
5	9	Female	10	100	105	130	105	25

ternal obturator muscles were different between the sides and these muscles were shorter but thicker at the treated side (Fig. 2). The ilium was osteotomised where the iliolumbar and cranial gluteal vessels were bent outwards to the lateral side of the ilial wing. Both vessels were seen as distinct structures at the untreated side, but there was an irregular vessel net at the treated side (Fig. 3). Caudal to these vessels, the ascending branch from the lateral circumflex femoral artery was determined both at the treated and untreated sides. The obturator branches were seen just caudal to the pubic osteotomy line and were close to the femoral head at the treated side (Fig. 2). The space between the ischiadic spine and the sacrotuberous ligament was found to be narrower than at the untreated side, causing a compression on the caudal gluteal vessels between the bone and the ligament at the treated side (Fig. 3).

The cranial gluteal nerve was seen at the level of the iliac bone plate, but its branch to the middle gluteal muscle was not determined at the treated side. When compared to the untreated side, the obturator nerve was more lateral and entered into the levator ani muscle more cranial at the treated side. The lumbar trunk of the sciatic nerve that was formed by the ventral branches of the sixth and seventh lumbar nerves was found to be enveloped by the thick fibrous tissue at the medial surface of the ilial body (Fig. 4).

Discussion

Triple pelvic osteotomy is a major surgical procedure and is aimed to establish the hip joint congruence. To achieve this aim, the regional anatomic structures have naturally undergone several changes such as atrophy

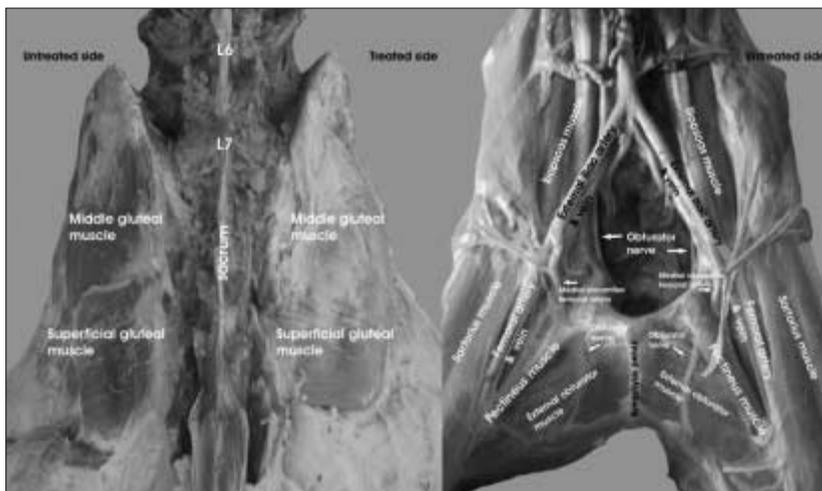


Figure 1: Atrophy (*) of the middle gluteal and pectineus muscles.

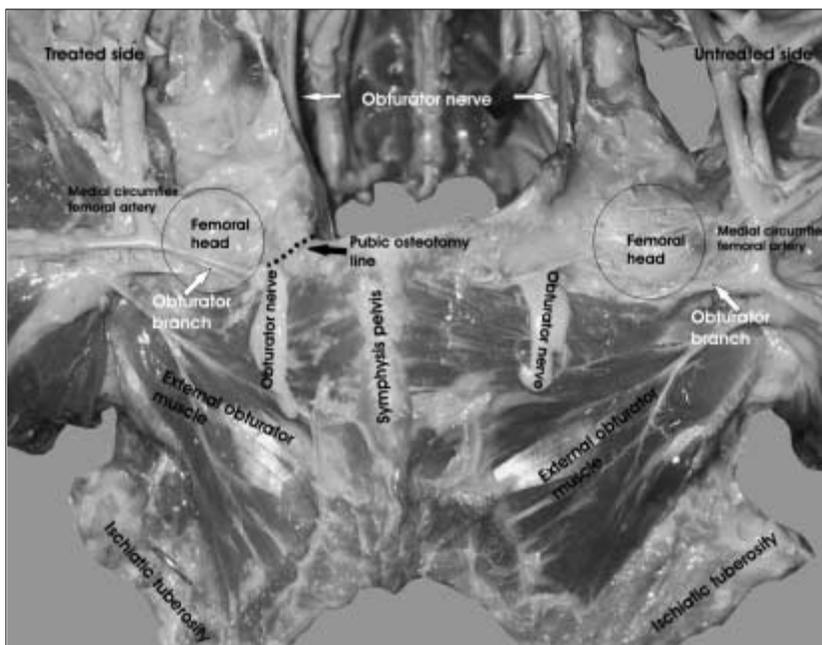


Figure 2: Ventral aspect of the pelvic region after removing the pectineus muscle.

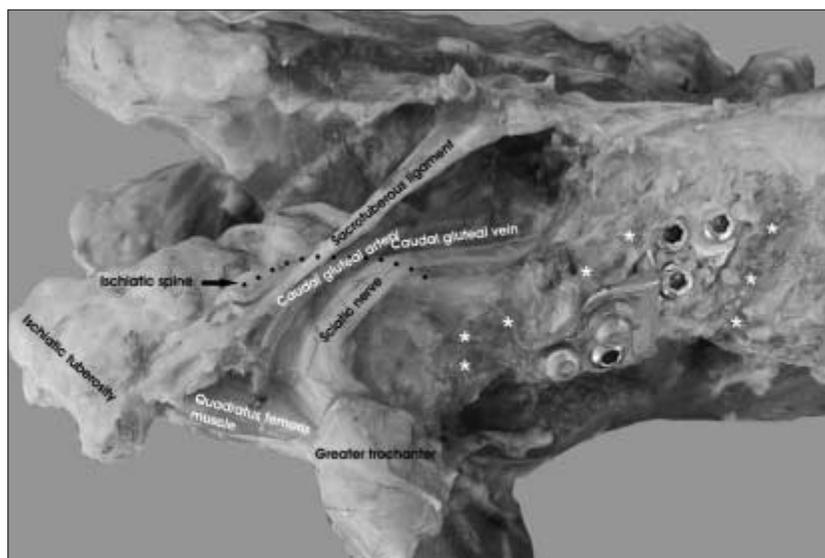


Figure 3: Lateral aspect of the pelvic region after removing gluteal muscles and the irregular arterial net (*) instead of cranial gluteal and iliolumbar arteries around the plate.

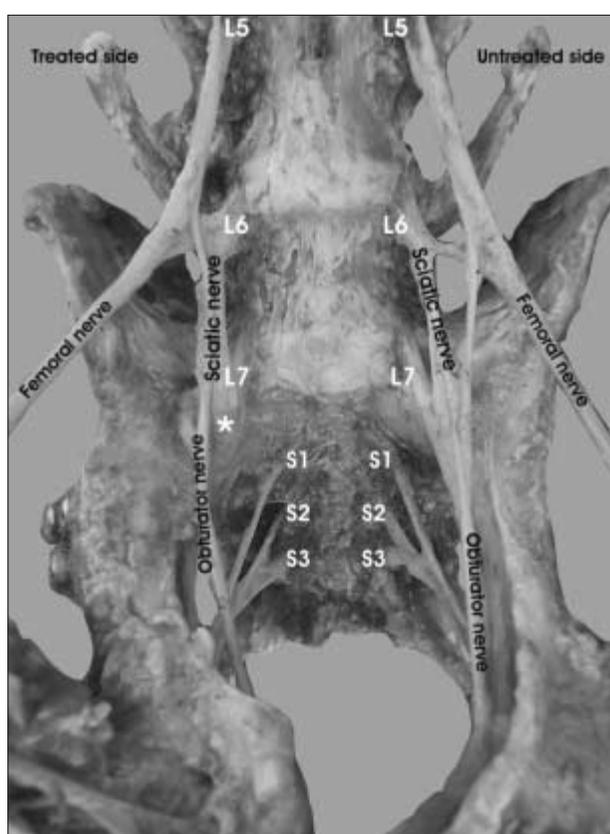


Figure 4: Major nerves around the pelvis and the thick fibrous tissue (*) medial to the ilial body.

and shape alterations in some regional muscles. The denervation atrophy of the middle gluteal muscle was considered as a result of the injury of branches from the cranial gluteal nerve, while the disuse atrophy of the pectineus muscle was caused by tenotomy. The origin and insertion areas of the internal and external obturator muscles came closer to each other as a result of the acetabular rotation. This caused the different appearance and reduced tension of these muscles at the treated side, which may cause the functional de-

ficiencies of the muscles. All these changes may partially explain why a compensatory load shift away from the treated limb is seen in cases of unilateral triple pelvic osteotomy after five weeks (McLaughlin et al., 1991). There is no doubt that higher muscular differences between the treated and untreated sides in the pelvic region can be obtained by electrophysiological studies.

Evans and Christensen (1979) reported that the middle gluteal muscle is supplied by three arterial sources: the iliolumbar artery, the cranial gluteal artery and the ascending branch of the lateral circumflex femoral artery. The former two arteries supply the cranial portion of the muscle while the latter one supplies the caudal portion. When performing triple pelvic osteotomy, it is suggested that the iliolumbar and cranial gluteal arteries should be ligated or preserved, respectively (Hulse and Johnson, 1997). In this study, these two arteries could not be preserved at the treated side most likely because of impaired blood flow to the cranial portion of the middle gluteal muscle. This mechanism plays also a role in the atrophy of the middle gluteal muscle observed in all treated dogs. Also, the displacement of bony structures under this muscle may be the reason for asymmetric appearance of the middle gluteal muscle. A lacerated obturator artery has been reported as a complication in the triple pelvic osteotomy (Schrader, 1986). In fact, this artery is absent in dogs and the obturator branch of the medial circumflex femoral artery takes the place of the obturator artery as found in other species (Evans and Christensen, 1979; Schummer et al., 1981). In our study, the obturator branch was seen in all dogs as an invariable structure, but its location was very close to the pubic osteotomy line. Therefore, care should be taken not to hurt this branch when the pubis is cut. The caudal gluteal artery and vein run distolaterally between the minor ischiadic notch and the sacrotuberous ligament. The rotation of the acetabulum

shortened the distance between the notch and the ligament at the treated side and the vessels, especially the large caudal gluteal vein, were compressed in this gap. In addition to the slow hemodynamic function of the veins, caused an additional handicap in returning blood from the caudal gluteal vein. This situation may explained the scrotal swelling as a complication of treated dogs (1%) after triple pelvic osteotomy (Borostyankoi et al., 2003).

The former studies have pointed out that special attention should be given to three nerves, the cranial gluteal, obturator and sciatic nerves during triple pelvic osteotomy (Schrader, 1986; Graehler et al., 1994; Hulse and Johnson, 1997; Simmons et al., 2001; Borostyankoi et al., 2003; Altunatmaz et al., 2003). However, only sciatic nerve damage was reported as a complication in respect of its functional importance (Simmons et al., 2001; Borostyankoi et al., 2003; Altunatmaz et al., 2003). In this study, the thick fibrous tissue that enveloped the sciatic nerve was determined at the medial surface of the ilial body, which may cause the neurological abnormalities.

In performing the triple pelvic osteotomy, the plates pre-angled between 20° and 45° are used according to the angles of subluxation and reduction. Graehler et al. (1994) documented that the significant differences at the pelvic architecture such as the pelvic inlet

area, the interischadic tuberosity distance, the acetabular area and the degree of acetabular version are seen depending on the degree of the axial rotation as well as the angle of the ilial osteotomy and type of the plates. Results of the present study provide some anatomical data of long term effects after triple pelvic osteotomy by using canine pelvic osteotomy plates with an angle of 20°.

In conclusion, findings of this study showed the changes of anatomical structures around the pelvis in average-sized dogs after unilateral triple pelvic osteotomy. The changes observed such as atrophy of the middle gluteal muscle, reduced tension of the external and internal obturator muscles, compression on the caudal gluteal vein and the entrapment of the sciatic nerve at the level of the ilial body were reported for the first time. It is clear that some changes in the regional anatomical structures are unavoidable, while some complications are directly related to the surgeons' experience. From the anatomical standpoint, the aforementioned changes seen by using a 20° canine pelvic osteotomy plate can easily be converted into complications depending on intolerable rotation of the acetabulum. Therefore, it is suggested that the lateral rotation of the acetabulum should be kept minimal to guarantee least alterations in the normal anatomic architecture of the pelvic region.

Effets de la triple ostéotomie pelvienne sur les structures anatomiques du bassin chez le chien

La triple ostéotomie pelvienne est utilisée chez les chiens souffrant de dysplasie coxo-fémorale pour améliorer la forme et la fonction anatomique de l'articulation de la hanche. Cette opération conduit en outre à différentes modifications dans la région du bassin. La présente étude avait pour but d'étudier plus exactement les modifications anatomiques consécutives à une ostéotomie pelvienne unilatérale chez cinq chiens croisés. Les modifications les plus marquées chez les chiens opérés consistaient en une atrophie du muscle gluteus medius, en une perte de tension des muscles obturateurs externes et internes et en une compression de la veine gluteale caudale ainsi que du nerf sciatique au niveau du corps de l'ilium. Au vu de ces constatations, il est recommandé de limiter au minimum la rotation latérale de l'Acetabulum, pour réduire les modifications anatomiques des structures normales du bassin.

Effetti di una triplice osteotomia del bacino sulla struttura anatomica nella zona del bacino nel cane

La triplice osteotomia del bacino viene utilizzata sui cani affetti da displasia dell'anca per migliorare la forma e la funzione anatomica dell'anca. Quest'operazione comporta inoltre vari cambiamenti nella zona del bacino. Questo studio ha lo scopo di analizzare in dettaglio i cambiamenti anatomici in 5 cani non di razza dopo una triplice osteotomia unilaterale del bacino. Le differenze più appariscenti nei cani operati erano un'atrofia del M. gluteus medius, una perdita di tono del M. obturator externus e internus, una compressione della vena gluteale caudale e del N. ischiadicus all'altezza dell'osso iliaco. Considerando questi punti di vista consigliamo di mantenere minima la rotazione laterale dell'acetabolo per minimizzare i cambiamenti anatomici della struttura normale del bacino.

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