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Double Pelvic Osteotomy (DPO) in Canine Hip Dysplasia - Clinical and Radiographic Evaluation

Nuriza Zamirbekova, Elgin Orçum Uzunlu & Mustafa Arıcan

ABSTRACT

***Background*:** Hip dysplasia (HD) in dogs is a common orthopaedic issue affecting both young and adult animals, leading to degenerative joint disease (DJD) and decreased quality of life. Various diagnostic methods, including radiography, are employed to assess the severity of the condition. Treatment options range from surgical interventions, such as juvenile pubic symphysiodesis (JPS) and pelvic osteotomies, to salvage procedures like total hip arthroplasty. This study focuses on the peri- and postoperative evaluation of double pelvic osteotomy (DPO) as a treatment option for dogs aged 4-6 months diagnosed with hip dysplasia.

***Materials, Methods & Results*:** In this study, 12 dogs aged 4-6 months were examined at the Surgery Department of Selcuk University's Faculty of Veterinary Medicine, either due to hind limb lameness complaints or for routine hip dysplasia examinations. Following clinical and radiological assessments, all dogs were diagnosed with hip dysplasia, and subsequently, a double pelvic osteotomy (DPO) was performed as the chosen treatment. Clinical examinations involved recording stair climbing, walking, and running gait patterns, along with conducting the Ortalani, Barlow, and Barden tests. Radiological assessments were conducted for ventro-dorsal radiographs, administered under medetomidine sedation. To accurately predict passive laxity in the coxofemoral joint, the distraction stress radiography technique was employed. This method utilized a neutral stance compression radiograph, an acrylic bar placed between proximal femurs, and assessment of subluxation based on the adduction force produced. The distraction index, calculated by measuring displacement between mid-acetabular and mid-femoral head, helped evaluate hip joint abnormalities. For the DPO procedure, sedation was administered using medetomidine, followed by the induction of anesthesia with either ketamine or propofol. In intubated cases, isoflurane was administered, and vital signs were continuously monitored. The surgical steps included osteotomy of the *os pubis* and *corpus ossis ilii*. The dog was positioned dorsolaterally for the pubic osteotomy, with careful preservation of vital structures. Subsequent osteotomy in the lateral recumbent position involved an incision from the iliac crest to the greater trochanter, with iliac vessels isolated and ligated. Protection of soft tissues during osteotomy was ensured using Hohmann retractors, and a 20% curvilinear osteotomy was performed on the exposed *ossis ala ilium*. Post-osteotomy, the caudal ilium was held laterally, and an osteotomy plate was fixed to the caudal line of the ilium. A caudally fixed osteotomy plate (left or right, 3.5, 25^0, 6 holes - 1 cortical, 5 locking) was then fixed to the cranial ilium by osteotomy reduction. This comprehensive approach, encompassing diagnosis, treatment, and surgical technique details, underscores the study's dedication to addressing hip dysplasia in young dogs, providing valuable insights for veterinary orthopaedics and patient care.

***Discussion*:** The study suggests that DPO is a viable alternative to traditional methods, with lower complication rates and positive clinical outcomes. The postoperative period showed promising improvements in various parameters, indicating the potential efficacy of DPO in treating hip dysplasia in growing dogs. Long-term follow-up and additional studies, including CT scan results, are recommended for a more comprehensive understanding of the surgical outcomes and to establish DPO as a safe and effective technique.

Keywords: bilateral pelvic osteotomy, distraction index, femoral inclination angle, hip dysplasia, Norberg angle.

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Department of Surgery, Faculty of Veterinary Medicine, Selcuk University, Konya, Turkey. CORRESPONDENCE: N. Zamirbekova [nuriza.zamirbekova@selcuk.edu.tr]. Department of Surgery, Faculty of Veterinary Medicine, Selcuk University. 42003 Konya, Turkey.

INTRODUCTION

Hip dysplasia (HD) is defined as subluxation or dislocation of the femur in young animals and abnormal development of the coxofemoral joint with degenerative joint disease in adults. HD may occur early and progress over time, leading to secondary coxofemoral osteoarthritis [9,19,23]. Progression of coxofemoral osteoarthritis leads to degenerative joint disease and can reduce the quality of life of pets. Hip dysplasia usually presents with clinical signs in puppies aged 5-9 months or in adults [9,11,12]. On physical examination, young dogs with dysplastic hips may present with pain or positive Ortolani sign when the hips are abducted or extended [1,4,5,11-13]. Dysplastic dogs may attempt to reduce the pain by shortening the strides when walking and may show an associated pelvis vibration [21]. Various pelvic radiographs can be used for diagnosis. Treatment protocols for hip dysplasia should be individualised and there are several surgical treatment options [1,4,5,11,12,21]. One of these options is the bilateral pelvic osteotomy technique [17,19].

Objective of the study: Peri- and postoperative evaluation of the bilateral pelvic osteotomy technique as a treatment option in dogs aged 4-6 months with a diagnosis of hip dysplasia. Our 2nd aim is to compare the peri-operative and post-operative clinical and radiological examination findings in dogs that have been treated with this technique. The angle of reduction, angle of subluxation, femoral head coverage and Norberg angle obtained from the radiographs, the interpretation and the measurements used for diagnosis will also be compared with the diagnostic methods and the results of treatment.

MATERIALS AND METHODS

Animals

Twelve dogs of different breeds and sex, aged 4-6 months, that were brought to the Surgery Department of the Faculty of Veterinary Medicine of Selcuk University with complaints of hind limb lameness or for routine examination of hip dysplasia were examined (Table 1). After clinical and radiological examination, the dogs were diagnosed with hip dysplasia. A double pelvic osteotomy was performed for the treatment of hip dysplasia.

Table 1. Distribution of race, breed, age (month) and operated area of the patients in the study.

Case	Race	Breed	Age	Operated area
1	Crossbreed	Famale	4	Right Corpus ilium, os pubis
2	Crossbreed	Male	5	Right Corpus ilium, os pubis
3	Kangal Shepherd Crossbreed	Male	4	Left Corpus ilium os pubis
4	Crossbreed	Famale	4	Left Corpus ilium os pubis
5	German Shepherd	Male	5	Left Corpus ilium os pubis
6	Kangal Shepherd Crossbreed	Famale	4	Right Corpus ilium, os pubis
7	Crossbreed	Male	4	Right Corpus ilium, os pubis
8	Crossbreed	Famale	6	Left Corpus ilium os pubis
9	Crossbreed	Famale	4	Left Corpus ilium os pubis
10	Kangal Shepherd Crossbreed	Male	5	Right Corpus ilium, os pubis
11	Kangal Shepherd Crossbreed	Male	5	Right Corpus ilium, os pubis
12	Crossbreed	Famale	4	Right Corpus ilium, os pubis

Clinical and radiological examinations and evaluations

Clinically, stair climbing, up and down walking and running gait patterns were recorded. The Ortalani test, the Barlow test and the Barden test were carried out and the forms recorded. For radiological examination Siemens, Sp-HF-4.0 Ralco[1], ventro-dorsal radiographs were taken under sedation with medetomidine HCL[2] [0.08 mL/kg, IM].

To better predict the degree of passive laxity of the coxofemoral joint, the distraction stress radiography technique was used (Figure 1). A neutral stance compression radiograph was used to calculate the distraction index score. For this purpose, an acrylic bar was placed between the proximal femurs and the presence of subluxation in dogs with hip joint abnormalities was assessed by the adduction

force produced. Distraction index was obtained by calculating displacement between mid-acetabular and mid-femoral head.

Surgery of Double Pelvic Osteotomy (DPO)

Sedation was administered with medetomidine HCl[2] [0.08 mL/kg, IM]. Ketamine HCl[3] [5-10 mg/kg, IV] or Propofol[4] [1-4 mg/kg, IV] were administered to sedated dogs under induction anaesthesia. In intubated cases, isoflurane was administered in a dose range of 2-3%. Fluid support was provided at a rate of 5-10 mL/kg/h for more than 30 min during surgery, depending on the anaesthetic combination. The depth of anaesthesia, heart rate, respiratory rate, oxygen saturation, end-tidal CO_2 ($EtCO_2$), temperature, blood pressure and colour of the mucous membranes were monitored by mindray[5] throughout the operation.

For the DPO, an osteotomy of the *os pubis* and the *corpus ossis ilii* was carried out. The dog was 1st placed in the dorsolateral position for the pubic osteotomy. The incision was then continued in a distal direction along the *musculus pectineus* to the upper 3rd of the femur. The cranial edge of the pubis was exposed, preserving the femoral artery, vein and nerve running along the cranial border of the muscle. Dissection was performed on the musculus pectineus. At the junction, the ileum was identified. Scraping was performed on the cranial, lateral and caudal pubic periosteum. The iliopubic eminence was used as the starting point. The osteotectomy was performed using a Hoffman retractor. The medial part of the origin of the pectineus is removed by ostectomy after periosteal elevation. Standard techniques are then used to suture and close the area.

The dog was positioned in the lateral recumbent position with the affected joint elevated. From the cranial edge of the iliac crest to the greater trochanter an incision was made. The centre of the incision was over the ventral 3rd of the *ala ossis ilium*. The superficial gluteal muscles and subcutaneous tissue were dissected along the same line until the intermuscular septum was reached between the *musculus latissimus dorsi*. The iliac vessels were isolated and ligated. A periosteal elevator was used to elevate the periosteum from the medial surface of the ilium. To protect the surrounding tissues during the osteotomy, 2 Hohmann retractors were placed cranially in the ilium (Figure 2). A 20% curvilinear osteotomy was performed on the exposed *ala ossis ilium* (Figure 3).

After the osteotomy, the caudal ilium was held in a lateral position with bone holding forceps and the osteotomy plate was fixed to the caudal line of the (Figure 4). Caudally fixed osteotomy plate[6] [left or right, 3.5, 250, 6 holes (1 cortical, 5 locking)] was then fixed to cranial ilium by osteotomy reduction (Figures 5 and 6).

Figure 1. In order to obtain a ventrodorsal, extended hip radiograph, the dog is placed in the supine position, the hind legs are extended caudally, and the radiographic image is obtained with a slight internal rotation of the femurs.

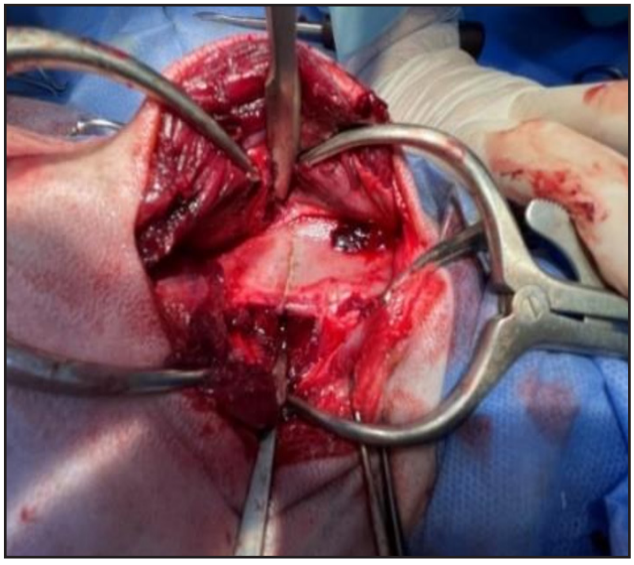

Figure 2. Placement of 2 Hohmann retractors in the ilium cranial to protect surrounding tissues during osteotomy.

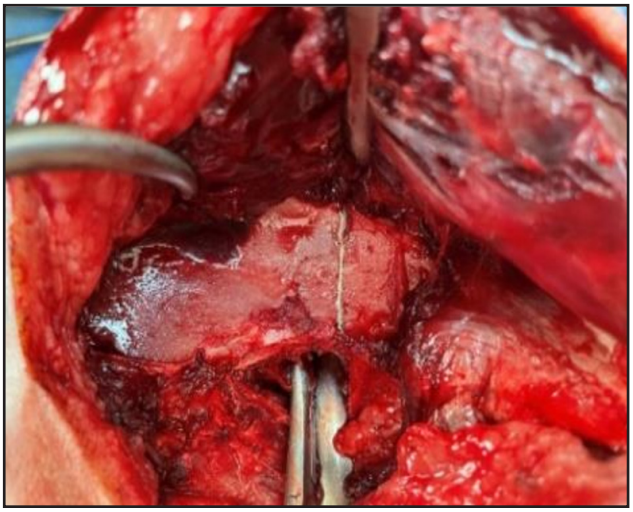

Figure 3. A 20% curved osteotomy was performed on the exposed *ossis ala ilium*.

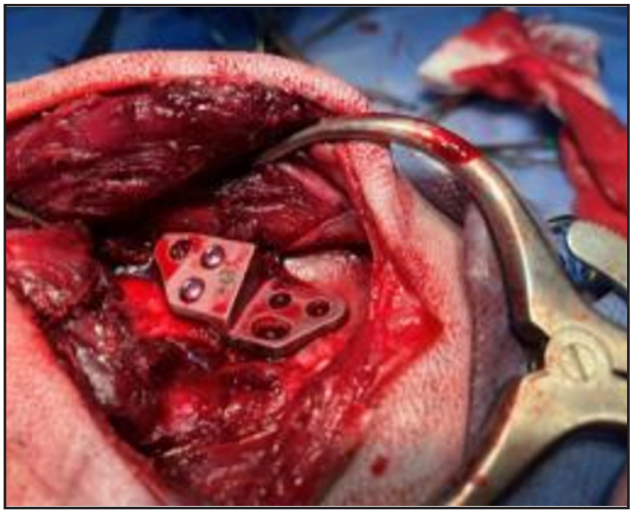

Figure 4. Lateralizing the caudal ilium with bone-retaining forceps after osteotomy and fixing the osteotomy plate to the caudal ilium line.

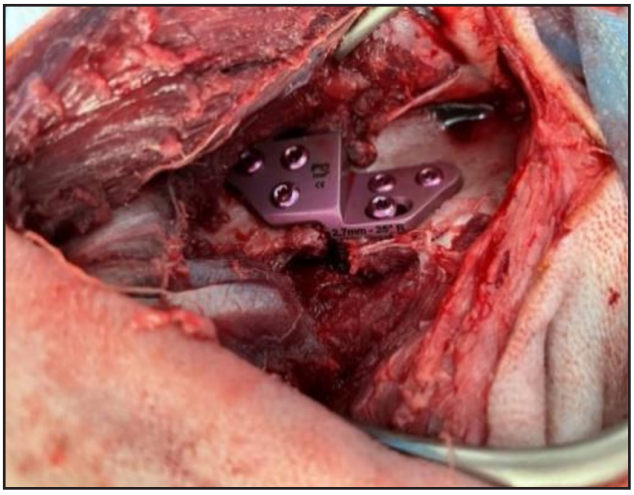

Figure 5. Fixation of the osteotomy plate fixed in the caudal part to the cranial ilium by subsequent osteotomy reduction.

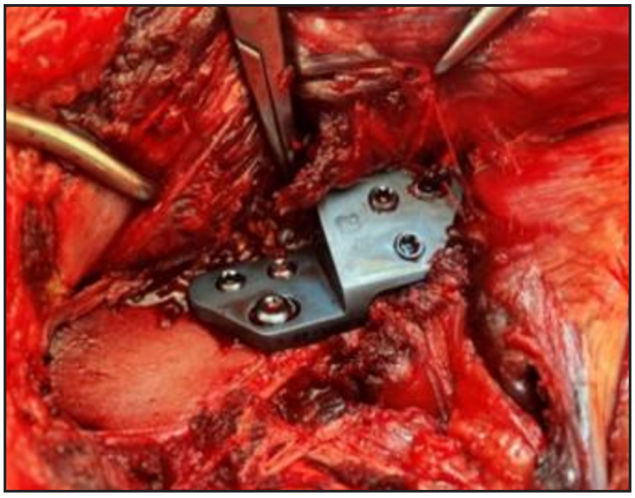

Figure 6. Intra-operative placement of the DPO plate on the angulated bone after osteotomy of the corpus ilium.

Figure 7. A large Norberg angle of 105º is generally considered normal, whereas angles less than 105º indicate hip laxity. The left radiograph shows that the Norber angle is less than 105 degrees in the left coxofemoral joint, and the right radiograph shows that it is less than 105º in both joints.

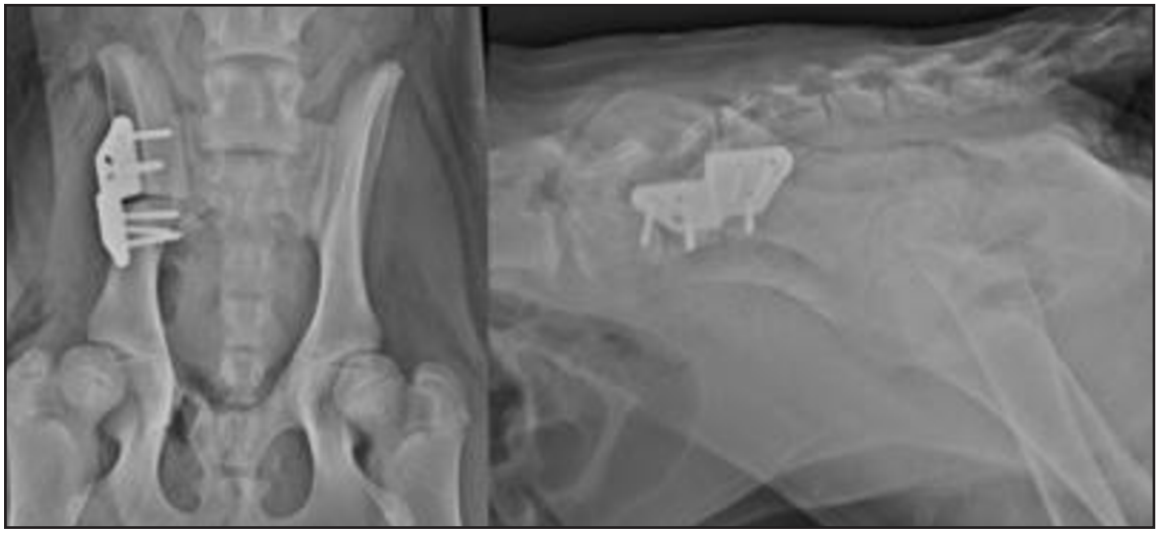

Figure 8. Ventro-dorsal and lateral post-op view of plate application.

RESULTS

Inspection was the 1st step in the clinical examination of the cases. The posture of the animal and the condition of the hindquarters were examined. In particular, in some cases there was evidence of tension in the hind limbs and a relative lengthening of the *articulatio genu* and *articulatio tarsi* joints due to the effort of the animal to put weight on the forelimbs. Atrophy of the *biceps femoris* muscle was also noted. Tests were performed for walking and climbing stairs. The gait of the patients was characterised by short strides and *pelvic oscillations*. In the stair climbing test (Table 2), "bunny hopping" was observed in some cases.

Sedation was used for the Ortalani, Barden and Barlow tests. In some cases, joint laxity was observed. The scoring was done subjectively (Table 3).

Radiological findings

The hip was radiographed in straightened position. The radiographs were used to record the Norberg angle, inclusion angle and acetabular depth. DI was determined using distraction stress radiographs.

A large Norberg angle of 105º is generally considered normal, whereas angles less than 105º indicate hip laxity.

The distraction index (DI) was calculated according to the degree of subluxation of the femoral head in the presence of subluxation using the distraction stress radiography technique and the PennHip method. The DI was scored from 0 to 1. A score of 0 indicates no subluxation and a score of 1 indicates complete dislocation of the joint. Although there were racial differences, DI scores greater than 0.3 were accepted as a cut-off for OA susceptibility (Table 4).

Post-operation follow-up

Dogs were advised to remain confined for 24-48 h following surgery. Butorphanol[3] [0.4 mg/kg, SC, QID] was used to control pain on the 1st day, followed by Meloxicam[7] [0.1 mg/kg, SC, QD, for the next 5 days]. Cefazolin[8] [20 mg/kg, IM, BID] was used as antibiotic prophylaxis for 10 days. Clinical and radiological examinations were performed for short-term follow-up (1 month). During the 1st 14 days, the dogs had restricted movement and in the following time (1 month) normal physical activity was progressively permitted. At 4, 6 and 8 weeks, clinical and radiological evaluations were performed.

DISCUSSION

An accurate method should be used for clinical examination and observation of hip dysplasia. The subjective Ortalani test, the Barden test and the Barlow test were performed under sedation during the clinical examination [2,3,13]. Because of the subjective nature of these tests, joint laxity has only been recorded in a few cases [2,21]. In all cases, clinical examination did not reveal a positive Barlow test result. However, the other tests used in the study were also positive.

Table 2. Performance of the cases in posture, sitting, walking and climbing stairs according to the results of the clinical examination.

Case	Standing Position	Siting Position	Gait	Stair climbing
1	Stiffness, Muscle loos in thights	Normal	Short steps, waddling gait	Normal
2	Muscle loos in thights	Leg extended to the side	Short steps, waddling gait	Bunny hopping
3	Muscle loos in thights	Normal	waddling gait	Normal
4	Normal	Normal	waddling gait	Normal
5	Stiffness, Muscle loos in thights	Normal	Short steps, waddling gait	Bunny hopping
6	Normal	Normal	Short steps, waddling gait	Normal
7	Muscle loos in thights	Leg extended to the side	Short steps, waddling gait	Normal
8	Muscle loos in thights	Normal	Short steps, waddling gait	Normal
9	Stiffness, Muscle loos in thights	Leg extended to the side	Short steps, waddling gait	Bunny hopping
10	Stiffness, Muscle loos in thights	Normal	Short steps, waddling gait	Normal
11	Stiffness, Muscle loos in thights	Normal	Short steps, waddling gait	Normal
12	Stiffness, Muscle loos in thights	Normal	Short steps, waddling gait	Normal

Table 3. Results of Ortalani, Barden and Barlow tests.

Case	Ortalani	Barlow	Barden
1	+	+	-
2	+	+	-
3	-	-	-
4	+	+	+
5	-	-	-
6	+	+	-
7	+	+	+
8	+	+	+
9	+	+	-
10	-	-	-
11	+	+	-
12	-	-	-

However, the most commonly used technique for the evaluation of hip dysplasia in the dog is the ventrodorsal radiograph of the hip in extension. Organizations such as the Orthopaedic Foundation for Animals (OFA), the Federation Cynologique Internationale (FCI) and the British Veterinary Association/ Kennel Club (BVA/KC) use this radiographic position most frequently. It evaluates the coxofemoral joint in relation to OA [1]. Although radiographic signs of OA are observed in the majority of cases of hip dysplasia, this finding does not appear until the later stages, when the disease process is being assessed. In all of the cases in the study, the femoral head was not fully inserted into the acetabulum on the dorsal and ventral sides. In all cases there was subluxation. Furthermore, joint subluxation was accepted as a diagnostic finding for hip dysplasia when hip radiographs did not show any OA findings (e.g. osteophytes).

Table 4. Norberg angles, inclination angles and distraction index results of the cases.

Case	Norberg Angle								Inclination Angle								Distraction Index 0.3 < less < 0.7							
	Right				Left				Right				Left				Right				Left			
	Pre operative data	Post operative 4^{th} week data	Post operative 6^{th} week data	Post operative 8^{th} week data	Pre operative data	Post operative 4^{th} week data	Post operative 6^{th} week data	Post operative 8^{th} week data	Pre operative data	Post operative 4^{th} week data	Post operative 6^{th} week data	Post operative 8^{th} week data	Pre operative data	Post operative 4^{th} week data	Post operative 6^{th} week data	Post operative 8^{th} week data	Pre operative data	Post operative 4^{th} week data	Post operative 6^{th} week data	Post operative 8^{th} week data	Pre operative data	Post operative 4^{th} week data	Post operative 6^{th} week data	Post operative 8^{th} week data
1	99	97	99	102	109	100	103	103	139	141	141	146	142	137	140	141	0.4	0.3	0.3	0.3	0.6	0.6	0.6	0.6
2	89	85	92	94	90	95	94	94	139	145	143	142	140	148	145	144	0.5	0.5	0.6	0.5	0.6	0.3	0.3	0.3
3	99	93	93	93	94	103	102	102	140	141	141	142	139	132	134	140	0.4	0.5	0.6	0.5	0.5	0.4	0.3	0.3
4	87	93	96	96	95	97	100	104	149	144	146	139	143	146	140	142	0.5	0.6	0.6	0.6	0.5	0.4	0.4	0.4
5	102	102	102	102	97	103	104	104	142	142	149	149	143	143	144	145	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3
6	87	92	100	102	94	97	97	97	145	144	144	143	147	147	149	149	0.7	0.5	0.3	0.4	0.4	0.6	0.6	0.6
7	92	94	98	102	93	101	100	100	142	144	146	148	145	145	145	148	0.7	0.5	0.5	0.5	0.6	0.6	0.6	0.6
8	103	103	103	102	98	97	97	98	151	150	148	148	143	140	141	144	0.6	0.4	0.4	0.4	0.6	0.5	0.5	0.5
9	102	102	104	102	94	96	98	98	141	148	145	145	143	144	143	142	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
10	87	92	94	100	98	96	97	96	144	142	143	142	142	142	142	143	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4
11	93	98	98	99	100	101	101	101	142	143	147	140	143	142	142	146	0.5	0.3	0.3	0.3	0.7	0.6	0.6	0.6
12	76	90	92	94	88	86	84	88	151	145	142	145	140	142	141	144	0.5	0.4	0.4	0.4	0.5	0.8	0.8	0.8

The Norberg angle was used to assess the degree of subluxation in these cases. It should be noted that excessive stretching of the joint capsule when radiographing the hip can cause the femoral head to sit deeper in the acetabulum, resulting in false negative radiographs in dysplastic hips [9]. A larger Norberg angle is indicative of a deeper acetabulum and a more harmonious hip, while a smaller angle is indicative of a greater degree of subluxation [4,18]. A Norberg angle greater than 105° is generally considered normal, while angles less than 105° indicate hip laxity [4,18]. As a measure of femoral displacement from the acetabulum, femoral overlap was also considered. Normal joint overlap is accepted to be 50%, and joint displacement was considered to be at values less than this [4,18]. In the project, almost 100% of cases had grade 2 and 3 dysplasia in the right and left coxae. According to the FCI scoring system, the preoperative Norberg angle of the coxofemoral joint was greater than 90° in 7 of 12 dogs and less than 90° in 5 dogs. The Norberg angle increased significantly in all patients at 8 weeks post-operatively.

In cases where the PennHip method was used with a distractor, joint laxity was measured. Animals were either deeply sedated or anaesthetised during this diagnostic procedure. Three radiographs were obtained, including a standard ventrodorsal hip image, a compression image in neutral, and a distraction image in neutral. For the distraction radiograph, an abutment (acrylic rod) was placed proximal to the femurs and the adduction force generated assessed for subluxation in dogs with hip abnormalities. If subluxation was present, the degree of femoral head subluxation was used to calculate the distraction index (DI). The DI was scored between 0 and 1, with a score of 0 indicating no subluxation and a score of 1 indicating complete joint dislocation. Compression radiography was used to assess joint compatibility. OA was considered early if there was no full compression and no full seating was observed. Ventrodorsal hip radiography is used to assess standard OA findings in the coxofemoral joint, as described by Smith *et al*. [22]. Distraction index scores of 0.5 for both joints in the postoperative period were accepted in this study. However, its ability to predict the later development of OA in young animals is the major advantage of the PennHip method. Reliability is affected by being able to assess dogs from 16 weeks old [18,22]. It should be noted that it can also provide reproductive control, particularly in breeds at risk, through its ability to determine the risk of developing OA at an early stage. It is often used to identify dogs requiring preventative surgeries, such as JPS, or other measures to prevent OA developing, such as restricting diet [22]. However, the definitive diagnosis of hip dysplasia is considered to be the observation of OA findings on radiographs [21]. As a result of the assessment of the DI, it is important that the DI starts to decrease in the post-operative period (< 0.5 initial values). If this is the case, there is evidence that the results of surgery have been successful.

In recent years, the surgical approach for patients with early dysplasia has been the triple pelvic osteotomy (TPO) [20,25]. This procedure demonstrated that the femoral head was well positioned dorsal to the hip socket [20]. However, following this procedure revealed a complication [20,22]. Consequently, the current technique is the dual pelvic osteotomy (DPO) [7,8,26]. DPO has been shown to have a lower rate of screw loosening in all studies [7,8,26]. In addition, the width of the pelvic canal was found to be better than in the TPO. There was no change in the angle of the acetabulum or the rate of complications [6,14,15,25]. Eight different double pelvic osteotomy plates were used in a total of 458 DPO operations (226 right, 232 left) in 2022 305 dogs: Fixin (n = 160), Kyon (n = 154), Next Generation Device (n = 63), Hofmann (n = 61), Veterinary Instrumentation (n = 12), DePuy Synthes (n = 4), Porte (n = 3) and Koenigsee (n = 1) [10,16]. The mean age of the dogs was 6.2 months (range: 5-8 months) and their weights ranged from 10 to 47 kg. A total of 42 complications occurred in 38 DPOs (8.2%). Complications included Green Stick fracture in the *os ischii* in 14 (3%), screw loosening in 13 (0.5%) of a total of 2,947 screws, screw fracture in 4 (0.8%), incomplete iliac fracture in 3 DPO (0.6%), partial caudal plate avulsion in 3 (0.6%), iatrogenic sciatic neuropraxia in 2 (0.4%), surgical site infection in 1 DPO (0.2%) and implant related pain and lameness in 2 permanent DPO (0.4%). In conclusion, DPO plates appear to be a safe surgical technique for treating hip dysplasia in growing dogs. There were no complication reports. Serious adverse events were low (0.6% major and 7.6% minor). The study showed that DPO is safe in 92% of cases [24] when using DPO plates and appropriate technique. There were no surgical complications observed in any of the cases in this study. However, it has been recommended that cadaveric studies be performed prior to performing this procedure [24,26]. Particularly for inexperienced clinicians, it can be difficult to locate the pubic bone. Knowing the anatomy of the region is intended to help avoid damaging the femoral

artery. In the study, the osteotectomy line was easy to find by following the *musculus pectineus*. The iliopubic eminence was used as the starting point. Osteotectomy was performed using a Hoffman retractor. The chances of success are increased when this operation is performed under fluoroscopy. However, reaching the iliac bone and determining the osteotomy line was much easier.

To avoid damage to the ischial and pudendal nerves, Hoffman retractors were used for the *os ilium* osteotomy. From the immediate caudal portion of the dorsal iliac spine, the osteotomy line was established. Before completing the osteotomy, the bone was separated with fine-tipped osteotomes and the caudal part of the ilium was osteotomised. Rotation of the plate was by means of a bone holder. The plate was placed on the incision line, towards the middle of the iliac crest. Towards the caudal segment of the ilium, the plate was 1st fixed. Particular care was taken with the dorsal fixation of the caudal segment. The fixation of the plate was on the dorsal aspect of the caudal segment. A comfortable rotation was thus ensured. To rotate, the following different techniques were used in some cases, the dorsal hole of the same segment was used for rotation. Sometimes the back of the iliac crest was cut to prevent damage to the gluteal musculature. Before this procedure can be performed, cadaver studies must be carried out. Once the procedure is learned, it is a simple step-by-step process.

At 4, 6 and 8 weeks post-operatively, the Norberg angles were approaching 105° degrees, the inclination angles were 140-150° degrees and the laxity values were < 0.5, indicating a favorable prognosis. The cases showed a positive progression in walking, running and stair climbing tests.

CONCLUSION

To conclude, as stated in previous studies, DPO is an alternative technique to TPO with fewer results and complication rates compared to the reference origins. In particular, when considering Norberg angles and DI, the 8-week postoperative results of DPO surgery in breeds predisposed to hip dysplasia were clinically positive. However, they noted that more cases should be followed for a longer period of time to better understand the surgical outcomes. In addition, the inclusion of CT scan results in the study will be more scientifically meaningful.

MANUFACTURERS

[1]Ralco S.R.L. Biassono, MI, Italy.

[2]Zoetis Türkiye. İstanbul, Turkey.

[3]Richter Pharma AG. Wels, Austria.

[4]B. Braun. Melsungen, Germany.

[5]Mindray Bio-Medical Elec. Co. Ltd. Shenzhen, China.

[6]Efesan. İstanbul, Turkey.

[7]Verano İlaç. İstanbul, Turkey.

[8]Mustafa Nevzat İlaç ve Kimyevi Maddeler San. Tic. A.Ş. İstanbul, Turkey.

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***Declaration of interest*.** The authors declare no conflicts of interest. Only the authors are responsible for the content and writing of this article.

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