V.C.O.T.

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Radiographic Evaluation and Comparison of Plate Fixation after Triple Pelvic Osteotomy in 32 Dogs with Hip Dysplasia

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Keywords
Hip dysplasia, triple pelvic osteotomy, radiology

The effect of triple pelvic osteotomy, as a treatment for canine hip dysplasia, was investigated retrospectively by means of radiographs. Acetabular support, the Norberg angle, and hip joint congruence improved significantly after the operation. Iliac osteotomy fixation, with the canine pelvic osteotomy plate, displayed advantages over the twisted dynamic compression plate. Screw loosening occurred frequently but without any major consequences.

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Summary

Triple pelvic osteotomy (TPO), as a treatment for canine hip dysplasia, was evaluated radiographically in 38 cases. Several parameters on radiographs of the pelvis, taken pre- and postoperatively, as well as six weeks and three months after the operation, were measured and compared. The results were also compared between iliac osteotomy fixation with the canine pelvic osteotomy plate (CPOP, n = 16) and the twisted dynamic compression plate (DCP, n = 22). Acetabular support (from 0.21 to 0.89), Norberg angle (from 77.6° to 111.8°) and hip joint congruence improved significantly after TPO. Dorsal pelvic width did not change, whereas, due to rotation, ventral pelvic width decreased to 80% of its pre-operative value. Osteophyte formation was judged to be moderate three months after the operation. Comparison of the two plating methods showed significant postoperative advantages for the CPOP group in terms of a higher Norberg angle and a better congruence. There was some loosening of 33% of the screws in both groups, but this did not interfere with the aim of the TPO procedure.

Introduction

Treatment of hip dysplasia in dogs can be conservative or surgical or a combination of the two. Throughout the study the decision was based on the severity of the illness, the radiological findings, the age and size of the dog, and financial aspects (1). Some of the most frequently used conservative methods are administration of drugs, dietary management to reduce the body weight, cage rest, controlled activity, physical therapy, or combinations of these (2, 3). These all help to alleviate the pain by diminishing the overloading on the hip joint and to develop the soft tissues to aid in hip stability. The aims of surgical therapy in dysplastic animals are to reduce pain, to return the gait to normal and, if practical, to prevent progression of degenerative joint disease (4). The variety of procedures employed includes pectineal myectomy (5), pelvic osteotomy (6–9), femoral osteotomy (10), total hip replacement (11), excision arthroplasty (12, 13), femoral neck lengthening (14), and acetabuloplasty (15, 16).

The idea of rotating the pelvis, in order to obtain better coverage of the femoral head by the acetabulum, was

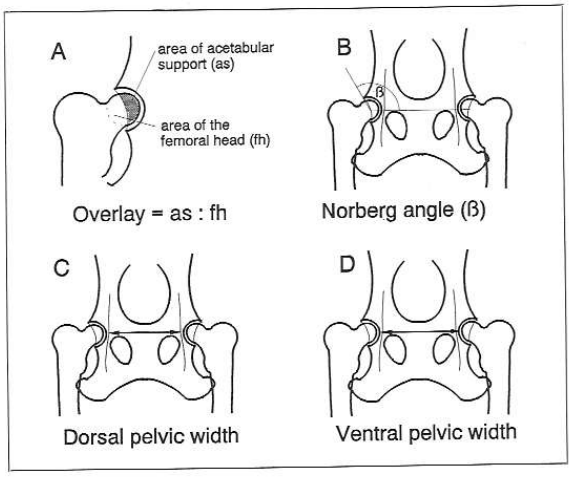

Fig. 1: Definitions of overlay (A), Norberg angle (B), dorsal pelvic width (C), and ventral pelvic width (D)

Table 1: Breed, plate design, age, sex and hip side of 32 dogs treated with triple pelvic osteotomy

Breed	Plate	Age (months)	Sex	Hip
Bernese mountain dog	CPOP	9	m	right
Bernese mountain dog (#1)	CPOP	9	m	right
Bernese mountain dog (#2)	CPOP	13	m	left
Bernese mountain dog (#1)	CPOP	11.5	f	right
Bernese mountain dog (#2)	CPOP	15.5	f	left
Bernese mountain dog	DCP	6.5	f	right
Bernese mountain dog	DCP	7	m	left
Bernese mountain dog	DCP	7	f	right
Bernese mountain dog (#1)	DCP	9	m	left
Bernese mountain dog (#2)	DCP	11	m	right
Bernese mountain dog (#1)	DCP	12.5	m	left
Bernese mountain dog (#2)	DCP	16	m	right
Rottweiler	CPOP	7	m	left
Rottweiler	CPOP	9	f	left
Rottweiler	CPOP	9	m	right
Rottweiler	DCP	9.5	m	right
Rottweiler	DCP	11	f	left
Rottweiler	DCP	12.5	f	left
Bouvier	DCP	8	m	left
Bouvier	DCP	11	m	left
Bouvier	DCP	13	f	left
German shepherd (#1)	DCP	8	f	right
German shepherd (#2)	DCP	10	f	left
German shepherd	DCP	10.5	f	right
Leonberger	CPOP	12	f	right
Leonberger	DCP	12	m	right
Golden retreiver	CPOP	15	m	left
Golden retreiver	DCP	7	f	right
Bobtail (#1)	CPOP	8	m	left
Bobtail (#2)	CPOP	15	m	right
St. Bernhard	CPOP	10	m	right
Flatcoated retreiver	CPOP	10	m	left
Collie	CPOP	11	m	left
Labrador retreiver	DCP	8	m	left
Newfoundland	DCP	9	m	left
Bullmastiff	DCP	10	m	right
Irish setter	DCP	10	m	right
Briard	DCP	21	f	right

#1 and #2 = successive triple pelvic osteotomies in the same dog. CPOP = canine pelvic osteotomy plate. DCP = dynamic compression plate

first described by Salter in 1961 (17) as innominate osteotomy for the treatment of congenital dislocation of the hip in children. Hohn and Janes (6) introduced this technique into veterinary medicine in 1969 by performing osteotomies through the ilium and the ischium. In the last ten years pelvic osteotomy has become more popular. A third osteotomy through the os pubis has been introduced and different methods to fix the rotated acetabular part of the ilium have been developed. Screws, wires, and twisted AO/ASIF[a] dynamic compression plates (DCP) were used (7, 9). Since 1987 canine pelvic osteotomy plates (CPOP)[b] have been available. These have a preformed angle of torsion of either 20, 30, or 45 degrees for either the right or the left pelvic side. In addition to the advantage over a DCP of absence of implant breakage, an avoidance of pelvic narrowing (18) has been claimed for its special design.

Triple pelvic osteotomy (TPO) is recommended for dogs with clinical and radiological signs of hip dysplasia but which do not have severe dysplastic malformations, including osteophyte formation and which have the presence of potential dorsal acetabular support for the femoral head. As a result, most of the potential candidates for TPO surgery are under one year of age. The prognosis after TPO is excellent, provided that there were suitable indications for the operation, followed by good surgical technique and good postoperative care (8, 19, 20).

The aim of the present study was to quantitate the effect of TPO, using radiographic parameters, and to compare the results between the technique of CPOP plating and DCP plating.

Materials and Methods

Thirty-eight TPO, which were performed based upon the diagnosis of hip dysplasia at the Department of Clinical Sciences of Companion

[a] Association for the Study of Internal Fixation

[b] Slocum Enterprises, Eugene, OR

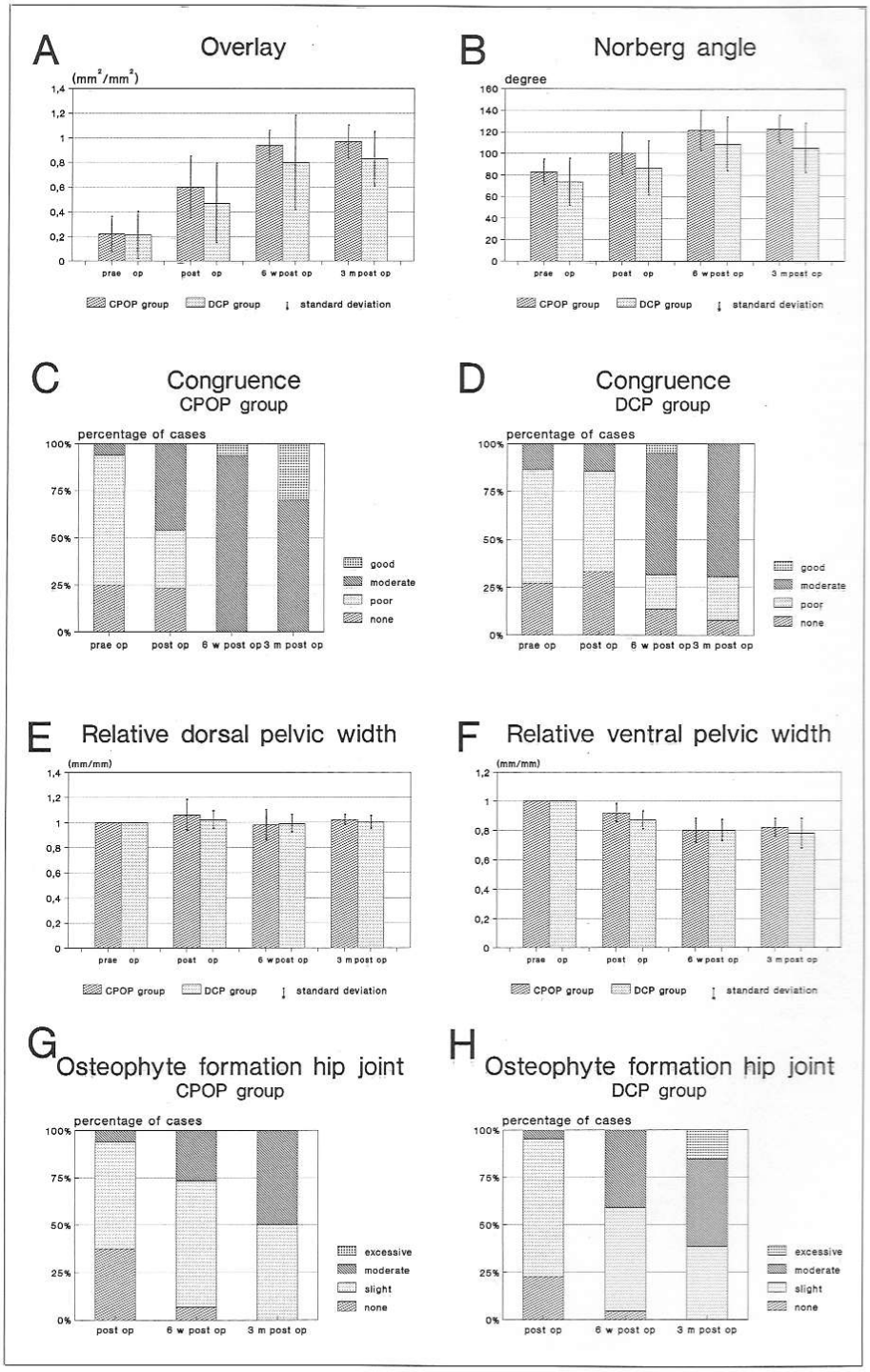

Fig. 2: Time evolution of overlay (A), Norberg angle (B), congruence (C, D), rDPW (E), rVPW (F), and osteophyte formation of hip joint (G, H) in 32 dogs before and after TPO as the treatment for hip dysplasia

Table 2: Screw size and type and screw loosening six weeks after 38 triple pelvic osteotomies

Screw type[1] and outer diameter	Screw loosening[2] Pos. 1[3]	Pos. 2	Pos. 3	Pos. 4	Pos. 5	Pos. 6	Total
2.7 mm cortical	1/1	2/2	2/2	0/2	0/1	0/2	5/10 (50%)
3.5 mm cortical	5/15	7/15	5/15	2/15	2/13	2/14	23/87 (26%)
3.5 mm cancellous	14/22	14/21	15/20	1/21	2/14	1/22	47/131 (37%)
4.0 mm cancellous	–/–	–/–	0/1	–/–	–/–	–/–	0/1 (0%)
Total	20/38 (53%)	23/38 (61%)	22/38 (58%)	3/38 (8%)	4/38 (11%)	3/38 (8%)	75/228 (33%)

[1] Synthes Ltd, Bettlach, Switzerland
[2] Screw loosening is indicated as: amount of screws loose after six weeks/total amount of screws placed
[3] Screws were numbered in the craniocaudal direction from position 1 to position 6. Positions 3 and 5 were the most ventral in the CPOP. The torsion point of the plate was always between position 3 and 4.

Animals at the State University of Utrecht between September 1986 and February 1991, were investigated. These 38 cases included all TPO in which follow-up radiographs were available for at least postoperative six weeks. The dogs were of different breeds, 12 were females and 20 were males, and their mean age at the first TPO was 9.5 months. Six of the 32 dogs were operated on bilaterally, with an intersurgical time span of at least six weeks (Table 1). TPO was carried out by four different surgeons following the technique described by Slocum and Devine (9, 18). Torsion angles of the plate were pre-operatively determined with the Ortolani and Barlow test during orthopaedic examination (21) and checked during the operation. Since the CPOP became available in 1987, the use of the CPOP and the 6-hole 2.7 mm DCP[c] was randomized, finally resulting in 22 cases with a DCP (DCP group) and 16 cases with a CPOP (CPOP group). In addition, the ischiatic osteotomy was held together with a cerclage wire in seven cases (six in the DCP group, one in the CPOP group). Radiographs of the pelvis, in the lateral and ventrodorsal positions, were made before and after the operation and at the follow-up examinations at six weeks (in all dogs) and three months (n = 23) postoperatively. Only two of the 32 dogs revealed moderate osteophyte formation before surgical treatment, whereas the remaining dogs revealed none or slight osteophyte formation.

On the radiographs, the following parameters were determined with a ruler, a planimeter, or a modified Norberg-Olsson protractor:

1. Overlay: The part of the area of the femoral head that is covered by the acetabulum on ventrodorsal radiographs. This area was related to the total area of the femoral head, to allow comparison of different sizes of dogs (Fig. 1A). Overlay was measured with a mechanical planimeter[d] as it is normally used for cartographic purposes.
2. Norberg angle: The angle which is formed between a straight line through the centres of both femoral heads and a straight line through the centre of the femoral head and the cranial acetabular rim (Fig. 1B).
3. Congruence: Similarity of the femoral and acetabular periphery in the hip joint, graded as none, poor, moderate, or good.
4. Dorsal pelvic width (only determined after unilateral TPO): The distance between the ilial bodies, on a line through the acetabular centres (Fig. 1C). This distance was related to its pre-operative value and expressed as relative dorsal pelvic width (rDPW).
5. Ventral pelvic width (only determined after unilateral TPO): The distance between the medial acetabular borders on a line through the acetabular centres (Fig. 1D). This distance was related to its pre-operative value and expressed as relative ventral pelvic width (rVPW).
6. Osteophyte formation around the hip joint, graded as none, slight, moderate, or excessive.
7. Plate torsion: The torsion of the DCP was calculated using ventrodorsal and lateral radiographs and trigonometric functions. The CPOP were preformed at angles of 20°, 30°, and 45°.
8. Screw type and screw position. Screw type: 2.7 mm cortical screw[e], 3.5 mm cortical screw[e], 3.5 mm cancellous screw[e], 4.0 mm cancellous screw[e]. Screw position: The screws were numbered, in the craniocaudal direction, from position 1 to 6. On the CPOP, screw positions 3 and 5 were the most ventral.
9. Occurrence of implant breakage and screw loosening. Screw loosening was defined as even the slightest difference in screw position on the follow-up radiographs, when compared with the postoperative position.

Statistical analysis, performed with the RS/1[f] software package: Student's t-test and the Wilcoxon rank test were used to calculate the differences in the parameters 1 to 6 between pre-operative and follow-up radiographs. The differences in parameters 1 to 6 between DCP and CPOP plating and the relation between screw loosening and the parameters 1 to 6 were calculated by multi-variant and single variant analysis. Correlation coefficients were calculated for plate torsion vs parameters 1 to 6. Single variant analysis was used to test the relationship of screw type, type of plating, and screw number to screw loosening. $P = 0.05$ was chosen as a level of significance. Values were given as mean ± standard deviation.

[c] Synthes Ltd, Bettlach, Switzerland
[d] G. Coradi AG, Zurich, Switzerland
[e] Synthes Ltd, Bettlach, Switzerland
[f] BBN Software Products Corporation, Munich, Germany

Results

The mean overlay increased significantly from 0.21 ± 0.17 before the operation to 0.53 ± 0.30 immediately postoperatively, to 0.86 ± 0.31 at six weeks postoperatively, and to 0.89 ± 0.20, at three months postoperatively. The Norberg angle was always below 105 degrees before the operation (77.6° ± 18.4°). Immediately after the operation, it increased significantly to 92.5° ± 23.4°, six weeks later to 114.3° ± 22.8°. By three months postoperatively, the mean Norberg angle was 111.8° ± 20.9° and 81% of the dogs had a Norberg angle above 105 degrees. Hip joint congruence was absent, or poor, before and immediately after the operation (89% and 74%, respectively). Congruence improved significantly during the first six weeks postoperatively and was judged to be moderate or good in 82% of the cases. The rDPW did not change but the rVPW decreased significantly to 80% ± 7% of its pre-operative value by six weeks postoperatively. Osteophyte formation, immediately after the operation, was graded as absent or slight in 95% of the TPO, but by six weeks and three months after the operation, it was absent or slight in only 65% and 43% of the cases, respectively (Figs. 2 and 3).

Multi-variant analysis was used to compare the plating methods, using as

Fig. 3: Ventrodorsal radiographs of the hip joints before (a), immediately after (b), and at six weeks (c), and three months (d) after triple pelvic osteotomy. Note the improved congruence and the higher acetabular support on the postoperative radiographs (CPOP).

variants the overlay, Norberg angle, congruence, rDPW, rVPW, and osteophyte formation. At six weeks and at three months after the operation there was a difference, in favour of the CPOP group over the DCP group. Single variant analysis demonstrated a statistically better congruence in the CPOP group after six weeks and three months and a statistically higher Norberg angle after three months. The differences in overlay, rDPW, rVDW, and osteophyte formation were not significant.

The CPOP were preformed using 45° in three cases and 30° in 13 cases. The DCP were twisted to 29.5° ± 6.5°. A correlation was not found between the angle of torsion and the six weeks-postoperative values for overlay ($r = -0.13$), Norberg angle ($r = -0.11$), congruence ($r = -0.04$), rDPW ($r = -0.40$), and rVPW ($r = -0.17$). None of the 228 screws was broken but 75 had loosened by six weeks (33%; Table 2). All TPO in which the same number of screws were loosened by six weeks and by three months after the operation were compared in terms of the overlay, Norberg angle, congruence, rDPW, rVPW, and osteophyte formation, but a significant difference was not found. The screws situated cranial to the torsion of the plate (positions 1, 2, 3) loosened significantly more often (58% of all cranial screws placed) than screws caudal to the torsion (positions 4, 5, 6; 10% of all caudal screws placed; Fig. 4). The difference in the numbers of screws loosened by six weeks after the operation between the CPOP group (52 of 132, 39%) and the DCP group (23 of 96, 24%) was not significant, nor were the differences between the 3.5 mm cortical screws and the 3.5 mm cancellous screws. The numbers of 2.7 mm cortical ($n = 10$) and 4.0 mm cancellous screws ($n = 1$) used did not allow statistical analysis (Table 2).

Fig. 4: Ventrodorsal radiograph of the hip joints three months after triple pelvic osteotomy. There is evident loosening of the most cranial screw.

Discussion

Triple pelvic osteotomy is one of the surgical techniques for the treatment of canine hip dysplasia. Its aim is to increase the acetabular support for the femoral head (6). This study retrospectively compared the effect within and between two plating methods using radiographic parameters. The use of radiographs, in order to evaluate hip dysplasia and postoperative results, has been well established (4, 9, 22) and permits easily available documentation for objective follow-up analysis.

In this study, the overlay, Norberg angle, and congruence increased after TPO in both the CPOP and the DCP group. Although they are all closely related and, when measuring the Norberg angle after rotation, the cranial acetabular rim may not reflect the same edge of bone, these parameters were used to describe the coxofemoral joint junction. Overlay was identified as the most reliable parameter for judgement of a successful TPO, because it reflects the amount of acetabular support for the femur. An increase in this support is the main goal of a TPO. The only limiting factor is the morphology of the acetabulum, which will change its radiological face individually due to the rotation. Within three months of re-evaluation, the overlay had increased by a factor of four, the Norberg angle had increased by 34° from 78° to 112°, and the congruence changed from poor to moderate. These radiological findings correspond with those in the literature. Schrader found an increase in the Norberg angle by 43° and 41° and a four-fold greater coverage of the acetabulum (7, 19). McLaughlin and Miller (23) found a 45° increase in the Norberg angle and demonstrated, using comparable parameters for femoral head coverage, an increase in overlay from 0.20 to 0.89. Congruence after TPO, which has been described as good by several authors (6, 7, 9), did not achieve the gradation "good" in the study. This may be explained by the fact that a subjective element in the judgement of congruence cannot be excluded; the congruence was defined differently by the authors.

The overlay, the Norberg angle, and congruence improved slowly and an increase was mainly observed between the postoperative and six-week radiographs. This gradual improvement has also been reported by others and is partly attributed to hip joint remodelling after TPO (23). The effect of anaesthesia on overlay, the Norberg angle, and congruence cannot be excluded (24), because radiographs directly after the operation were made in anaesthetized dogs that had then not used the extremities, whereas most follow-up examinations were made routinely without general anaesthesia. In addition, muscle development, in these dogs, may have contributed to the overall radiographic improvement and hip joint effusion may have been reduced concomitantly.

Comparison of the two plating methods showed that the CPOP method resulted in better congruence and improvement in the Norberg angle. This difference may be related to the different design of the implant. Since a correlation was not found between the angle of torsion of the plate and the postoperative values of overlay, Norberg angle, and congruence and that of all of these parameters increased, it may be concluded that the proper angle of torsion, in the given situations, has been employed.

The dorsal pelvic width, only measured after unilateral TPO, did not change during the three months and differences between the two groups were not evident. Most probably pelvic narrowing due to TPO, which has been described using a DCP (18, 25), was compensated for by growth of the pelvis in young dogs. The reported widening of the pelvis, when using a CPOP (18, 26) was not confirmed by our techniques. The dorsal acetabular rim view used by Devine and Slocum (27) to judge the femoral head coverage requires special precautions, including anaesthesia; whereas the technique described here is suitable for employment in an outpatient clinic. Reduction of the ventral pelvic width to 80% of its pre-operative value was due to rotation of the pelvis during the operation. The size of osteophytes, visible on the radiography around the hip joint, increased considerably during healing in both groups. These results need to be studied in a long-term investigation.

One of the major complications, reported with pelvic osteotomy, is implant failure (18, 25, 28). In our study 33% of all of the screws loosened, to a maximum amount of two full threads in a single case, but deleterious effects on bone healing were not seen, and the osteotomies healed, radiographically, within three months. Furthermore the overlay, the Norberg angle, and congruence were not affected by the number of screws loosened in each plate. This may be explained by the fact that other screws maintained the alignment or that loosening took place after the first phase of callus formation, or that the direction of the forces did not worsen the situation. Screw loosening was related neither to the plating method nor to the type of screw. This confirmed the results of a previous investigation (25) that showed that the holding power of the 3.5 mm cortical screw and 3.5 mm cancellous screw in pelvic bone did not differ.

Screw loosening may be related to a variety of causes, such as poor surgical technique, material failure, idiosyncratic reasons, or inappropriate postoperative management (29). Based upon experiences in other fracture treatment with basically the same techniques, the first option may be excluded in our study. Three factors will have contributed to the high frequency of screw loosening: first, the relatively small size of the implant in terms of stable osteosynthesis; second, the need for early weight-bearing after the operation because of the frequently bilateral nature of hip dysplasia; and third, the relatively weak holding power of screws in the juvenile bone. Because of conflicting results (2, 9, 19, 25) the need for a cerclage wire to stabilize the ilial osteotomy remains uncertain but it was not applied in our patients. Screws loosened, in most cases, cranial to the torsion point of the plate, as was also reported by Hunt and Litsky (25), who attributed this phenomenon to the bone struc-

ture in the iliac wing and to imperfect plate contouring to the bone cranial to the torsion point. However, in a previous report (9), screw loosening occurred mainly in the caudal segment of the ilium. According to the preference of the surgeons and recommendation in the literature (25), the screws cranial to the plate torsion were often placed through the iliosacral joint into the sacral body in order to obtain a deeper anchorage. It is therefore also possible that a certain movement in the iliosacral joint of a young dog would contribute to loosening of the screw.

Conclusions

TPO is an effective treatment for canine hip dysplasia which has been diagnosed in an early stage. This was confirmed by analyzing radiographs of 38 TPO in 32 dogs. The overlay, the Norberg angle, and the congruence improved significantly. Plating with the CPOP offered advantages over the DCP because the Norberg angle and congruence reached higher values. Differences were not observed between the techniques with regard to the postoperative pelvic widths. The large number of loosened screws, particularly cranial to the plate torsion, necessitates further investigation but did not interfere with the aim of the TPO procedure.

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