NOTE *Surgery*

Changes of Hip Joint Congruity after Triple Pelvic Osteotomy in the Dog with Hip Dysplasia

Yasushi HARA[1)], Yasuji HARADA[2)], Yukihiro FUJITA[1)], Takahiro TAODA[1)], Yoshinori NEZU[1)], Shinya YAMAGUCHI[1)], Hiromitsu ORIMA[3)] and Masahiro TAGAWA[1)]

[1)]Divisions of Veterinary Surgery and [3)]Veterinary Radiology, School of Veterinary Medicine, Nippon Veterinary and Animal Science University, 1–7–1, Kyonan-cho, Musashino-shi, Tokyo 180–8602 and [2)]Institute for Frontier Medical Sciences, Kyoto University, 53 Kawahara-cho, Shogoin, Sakyo-ku, Kyoto 606–8397, Japan

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ABSTRACT. Changes in hip joint congruity was evaluated in dogs with hip dysplasia before and after triple pelvic osteotomy by computed tomography examination in the standing position. Lateral center edge angle significantly increased, and center distance (CD) significantly decreased after surgery compared to the values before surgery, respectively. There was an inverse proportion between the postoperative period and the change in the ratio of CD. These results suggested that joint laxity was improved with time after surgery, providing evidence of the clinical usefulness of this surgery.

KEY WORDS: canine, hip dysplasia, triple pelvic osteotomy.

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Canine hip dysplasia (CHD) has been recognized to be a heritable developmental orthopedic disease that relatively often occurs in large- to giant-sized dogs [15]. Many surgical procedures for treatment of CHD have been reported, among which, triple pelvic osteotomy (TPO) was introduced from the field of human orthopedics by Slocum B. and Schrader S.C., in the 1980s [11–13]. There have been a number of clinical studies on TPO, including the surgical procedures, postoperative complications, postoperative locomotive function of the hindlimb, and biomechanical effects on the hip joint congruity [2, 3, 6–8]. TPO is a commonly performed procedure and is currently recognized as a preventative surgical procedure for hip dysplastic dogs without secondary osteoarthritis (OA) in sekeletally immature stage [8, 12, 13, 15]. However, the reversing effects of this procedure on joint laxity have not been studied in detail. In this study, we performed computed tomography (CT) examination for the hip joint of dogs with hip dysplasia before and after TPO, and evaluated the effects of TPO on the hip joint congruity.

This prospective study was undertaken in 8 dogs (16 hip joints) undergoing bilateral TPO for treatment of CHD in the Veterinary Medical Teaching Hospital of Nippon Veterinary and Animal Science University. The animals consisted of 5 breeds (6 males and 2 females). Their age ranged from 6 to 14 months (mean, 8.9 months), and the body weight ranged from 12.0 to 36.2 kg (mean, 26.3 kg) at the first surgery. The cases selected for this study were dogs that were diagnosed as bilateral hip displasia, initially admitted with clinical signs (lameness, pain), accompanied with no secondary degenerative change in the hip joint on the radiograph, and being approximately 20° to 30° of the reduction angle by preoperative Ortolani and reduction/subluxation tests [1, 5, 10, 13, 15].

TPO was performed according to the technique reported by Slocum and Devine [13]. Briefly, a pubic ostectomy and release of the pectineal muscle were done on the treatment side of pelvis, followed by an ischial osteotomy along the outer boundary of the obturator foramen. Then, the ilial osteotomy was done on a line perpendicular to the long axis of the hemipelvis, and the acetabular fragment was separated from the other part of pelvis. After rotation of the acetabular fragment to the ventral direction, the 16 iliums were fixed in all animals using 30º pre-angled plates and cortical bone screws (diameter, 3.5 mm; length, 18–32 mm; Mathys, Bettlach, Switzerland).

Computed tomography (CT) scan was performed under the position according to the procedure previously reported with a minor modification [4, 9, 14]. The dogs under isoflurane anesthesia were positioned on a laboratory-made platform in ventral recumbency. Our scanning technique were different from those mentioned in other reports in the following. Firstly, dogs were carefully positioned to make the bilateral femoral bones perpendicular to the imaging platform in the lateral Scout-view image, and to make the sacral vertebrae parallel to the imaging platform on CT transverse slices in the sacral region, and to make the axis of the bilateral femoral bones parallel and perpendicular to the imaging platform on CT transverse slices in the hip joint region. Secondly, the dog was kept with its hind legs suspended without external pressure or traction on the hip joint. Under the above position, transverse slices in the center of the hip joint was scanned at a width of 2 mm. Scanned CT slices were magnified 3.25–5.20 times with 300 Hunsfield unit (HU) in the window level and 1,500 HU in the window width, respectively. The lateral center edge angle (LCEA) and the center distance (CD) were then measured. The LCEA was defined as the angle determined by the dorsal edge of the acetabulum, the center of the femoral head, and horizontal line on CT images, and the CD was defined as the distance between the center of the femoral head and that of the acetabulum on CT images (Fig. 1).

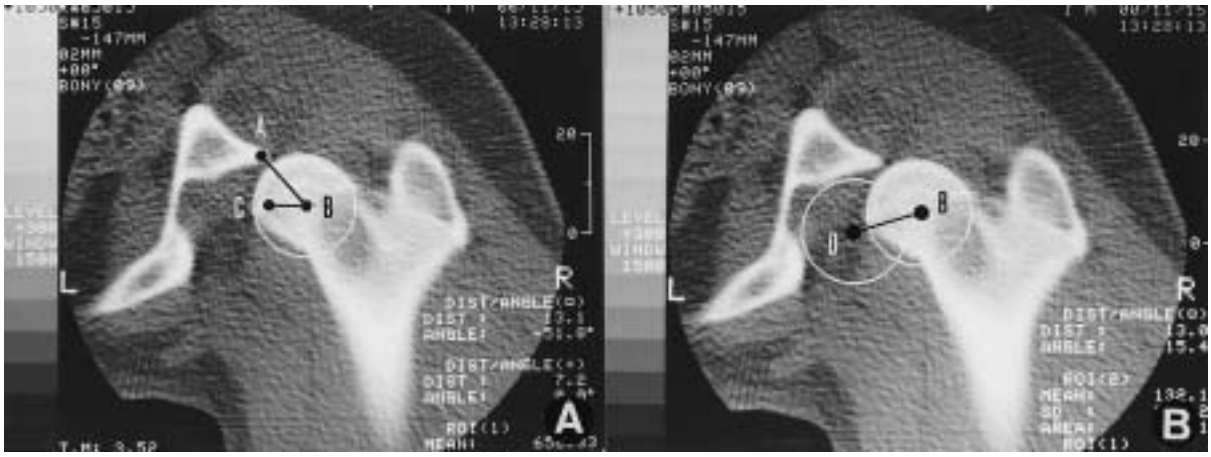

Fig. 1. Measurements of the parameters reflecting hip joint congruity. A: Measurement of the lateral center edge angle (LCEA). The LCEA was defined as the angle determined by the dorsal edge of the acetabulum (A), the center of the femoral head (B), and horizontal line (B-C) on a CT image. B: Measurement of the center distance (CD). The CD was defined as the distance between the center of the femoral head (B) and that of the acetabulum (D) on a CT image.

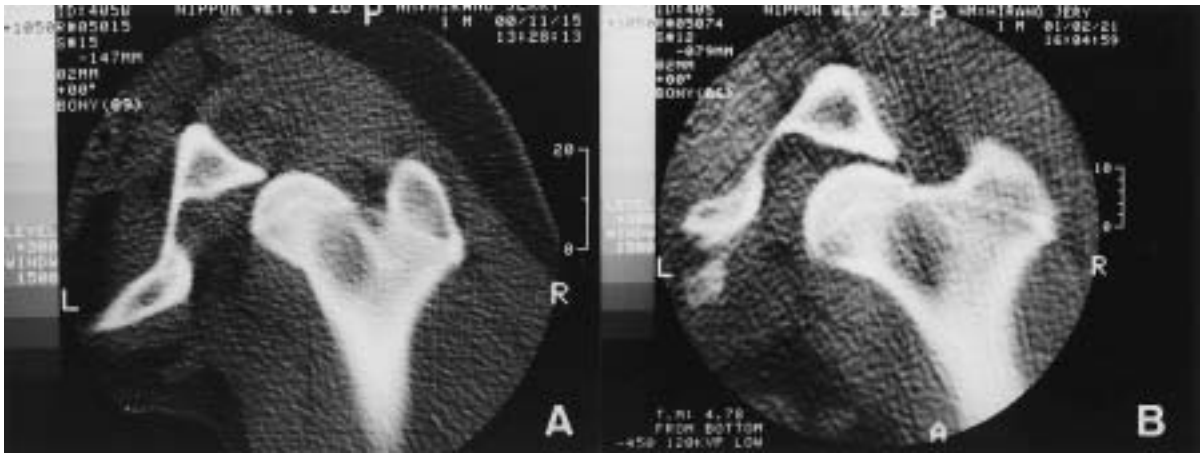

Fig. 2. Pre- and postoperative computed tomographic images of Case No. 7. A: Preoperative transverse computed tomographic image. B: Postoperative transverse computed tomographic image. The femoral head coverage by the acetabulum, reflecting the load-bearing area of the articular surface, was significantly improved after surgery.

The LCEA and CD measured before and after surgery by CT examination were analyzed with a one-way analysis of variance. Significant differences were determined with a Fischer test. Significance was established at $p<0.05$. Moreover, CD ratio was determined as the rate of the post- to preoperative value of CD. The relationship between the postoperative period and the CD ratio was also evaluated by correlation analysis.

In all of the 8 dogs in this study, TPO was separately performed in bilateral hip joints. The second surgery in the contralateral joint was performed 14–161 days (mean, 38.9 days) after the first surgery. The hip joint congruity was evaluated 7–422 days after each surgery (mean, 116.5 days). In the 8 dogs, postoperative complications were not observed, and the preoperative clinical signs such as hip pain and lameness of the hindlimb disappeared within about two months after surgery.

Figure 2 shows the CT transverse images of the hip joint before and after surgery in Case No.7. The pre- and postoperative LCEA values were 34.3º–90.0º (mean, 63.3º) and 76.5º–135.0º (mean, 110.0º), respectively. The pre- and post-operative CD values were 5.0–16.0 mm (mean, 9.1 mm) and 3.2–12.9 mm (mean, 6.0 mm), respectively (Table 1). The LCEA was significantly higher after surgery than before surgery ($p<0.001$), while the CD was significantly lower after surgery than before surgery ($p<0.05$). There was an inverse proportion between the postoperative period and the change ratio of CD in all hip joints ($n=16$, $r=0.538$, $p=0.03$) (Fig. 3). On the other hand, there was not a correlation between the postoperative period and the change ratio of LCEA.

Many clinical studies have suggested that CHD is started

Table 1. Changes of lateral center edge angle (LCEA) and center distance (CD) after triple pelvic osteotomy

Case No	Breeds	Sex	Site of surgery	Age at surgery (month)	Body weight (kg)	Duration[a)] (day)	LCEA (degree)		CD (mm)	
							Pre-ope	Post-ope	Pre-ope	Post-ope
1	Labrador Retriever	Male	Right	6	24.0	209	90.0	128.8	9.1	3.5
			Left	12	26.7	48	81.0	90.0	7.2	7.3
2	Labrador Retriever	Female	Right	9	22.6	23	56.4	113.0	7.3	6.2
			Left	9	22.0	7	71.0	102.2	5.0	4.9
3	Welsh Corgi Cardigan	Male	Left	8	12.0	46	51.3	84.9	6.3	5.7
			Right	9	12.5	13	58.3	110.0	6.6	4.7
4	Labrador Retriever	Male	Right	7	25.8	422	76.5	124.0	6.3	3.4
			Left	8	23.5	401	77.2	135.0	7.6	3.2
5	Bernese Mountain Dog	Male	Right	6	32.9	54	73.1	120.0	8.5	3.7
			Left	6	32.9	40	86.4	125.0	6.2	4.6
6	Flat Coated Retriever	Spayed female	Left	14	26.0	100	34.9	115.0	12.2	5.2
			Right	14	26.0	84	76.3	120.0	7.0	5.9
7	Golden Retriever	Male	Left	9	32.0	99	52.6	120.0	12.2	5.9
			Right	10	30.0	85	51.8	113.3	13.0	7.3
8	Labrador Retriever	Male	Left	7	36.2	135	34.3	76.5	16.0	12.2
			Right	8	35.6	98	41.6	81.5	14.9	12.9
	Mean			8.9	26.3	116.5	63.3	110.0	9.1	6.0

a) Duration means the interval between the pre- and the post-operative CT examinations in each leg of the dog.

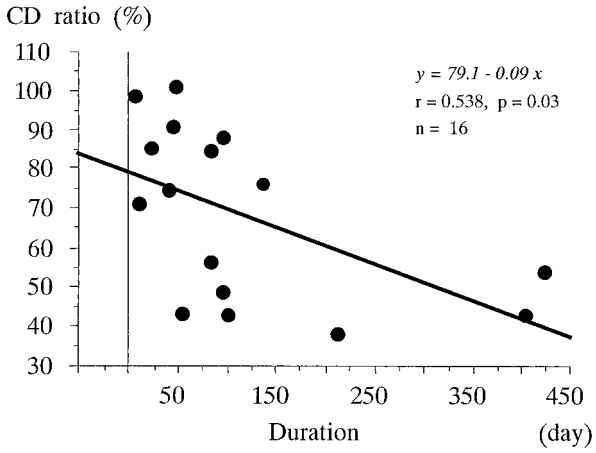

Fig. 3. Correlation between the postoperative period and center distance (CD) ratio. CD ratio was determined by the formula as follows.

$$\text{CD ratio (\%)} = \frac{\text{CD of post-ope}}{\text{CD of pre-ope}} \times 100$$

There was an inverse proportion between the postoperative period and the change ratio of CD in all hip joints (n=16, r=0.538, p=0.03).

by abnormal laxity and incongruency of the hip joint in skeletally immature dogs younger than 1 year of age, and that the reduced load-bearing area of the articular surface causes the secondary OA [3, 5, 15]. In such a clinical course of CHD, TPO is considered to be a preventive surgical method for skeletally immature dogs with hip dysplasia before the development of secondary OA. The clinical effect of this procedure is considered to increase the femoral head coverage, resulting to increase the load-bearing area and to reduce cartilage injury by dispersing mechanical stress on the articular cartilage [2, 3].

In the present study, the LCEA was significantly higher after surgery than that before surgery, while the CD was significantly lower after surgery than before surgery. Riley, *et al.* also showed that LCEA was increased significantly after TPO surgery in their experimental study using dysplastic dog cadavers [9]. Although there have not been many studies on the normal values of CD, the change of CD was considered to show the improvement of joint laxity and subluxation by surgery. Moreover, it was confirmed that there was an inverse proportion between the postoperative period and the change ratio of CD. In particular, the gradual decline of the CD after surgery was considered to show the gradual improvement of abnormal joint laxity, that was the characteristic of skeletally immature CHD.

Dejardin, *et al.* indicated that the contact area of the hip joint was markedly improved using 20º pre-angled plates [3]. However, it has been recommended that the ventroversion angle of the acetabular fragment in TPO surgery is determined by preoperative Ortolani and reduction/subluxation tests [13]. In the 8 dogs presented here, the reduction angle was about 20º–30º, and we selected 30º pre-angled plates.

The subjective radiographic scoring, as recommended by the Orthopedic Fundation for Animals, and measurements of Norberg angle have been accepted methods of quantifying hip integrity [10]. Although secondary OA with degenerative changes including osteophytes in the hip joint can be identified quite readily, it has been pointed out that the standard radiographic positioning with hindlimbs pulled caudally does not demonstrate coxofemoral laxity reliably because of the nonphysiological tensioning of the pelvic muscles, and twisting of the joint capsule [5]. In the present

study, we performed CT scan evaluation of hip joints in the standing position, and measured the LCEA and CD [9]. Since in this method, dogs under general anesthesia are held in the standing position without excessive extension or flexion of the hindlimbs on the imaging platform, abnormal tensioning or twisting is not induced in the joint capsule. Therefore, the degree of joint laxity between the femoral head and acetabulum can be accurately evaluated [4, 9, 14].

Although further studies may be necessary to fully understand the phenomena observed in this study, they might be due to the formation of joint-supporting tissues such as periarticular fibrosis and the reinforcement of the supporting tissues around the hip joint with growing. The results of this study suggested that abnormal joint laxity was gradually improved after TPO in the skeletally immature dogs with hip dysplasia, providing evidence of the clinical usefulness of TPO surgery.

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REFERENCES

1. Chalman, J.A. and Butler, H.C. 1984. *J. Am. Anim. Hosp. Assoc.* **21**: 671–676.
2. Dejardin, L.M., Perry, R.L., Arnoczky, S.P. and Torzilli, P.A. 1996. *Vet. Surg.* **25**: 114–120.
3. Dejardin, L.M., Perry, R.B. and Arnoczky, S.P. 1998. *Vet. Surg.* **27**: 194–202.
4. Farese, J.P., Todhunter, R.J., Lust, G., Williams, A.J. and Dykes, N.L. 1998. *Vet. Surg.* **27**: 393–405.
5. Fluckiger, M.A., Friedrich, G.A. and Binder, H. 1999. *Vet. Surg.* **28**: 1–9.
6. Graehler, R.A., Weigel, J.P. and Pardo, A.D. 1994. *Vet. Surg.* **23**: 13–20.
7. McLaughlin, R.M., Miller, C.W., Taves, C.L., Hearn, T.C., Palmer, N.C. and Anderson, G.I. 1991. *Vet. Surg.* **20**: 291–297.
8. Plante, J., Dupuis, J., Beauregard, G., Bonneau, N.H. and Breton, L. 1997. *Vet. Comp. Ortho. Traumatol.* **10**: 101–110.
9. Riley, S.M., Miller, C.W., Dobson, H. and Binnington, A.G. 1996. *Vet. Comp. Ortho. Traumatol.* **9**: 152–157.
10. Rendano, V.T. and Ryan, G. 1985. *Vet. Radiol.* **26**: 170–186.
11. Salter, R.B. 1961. *J. Bone Joint Surg.* **43-B**: 518–539.
12. Schrader, S.C. 1981. *J. Am. Vet. Med. Assoc.* **178**: 39–44.
13. Slocum, B. and Devine, T. 1986. *J. Am. Anim. Hosp. Assoc.* **22**: 331–338.
14. Swainson, S.W., Conzemius, M.G., Riedesel, E.A., Smith, G.K. and Riley, C.B. 2000. *Vet. Surg.* **29**: 178–190.
15. Wallace, L.I. and Olmstead, M.L. 1995. pp. 361–393. *In*: Small Animal Orthopedics (Olmstead,M.L. ed.), Mosby-Year Book, Inc., Missouri, U.S.A.