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RESEARCH ARTICLE

Evaluation of Clinical Outcomes of Cementless Porous Structured Total Hip Prosthesis in Dogs

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A B S T R A C T

In this study, total hip replacement (THR) was performed by using implants from the Innoplant company on 30 dogs and 33 cases. The average weight of the dogs was 33.05 ± 11.15, and their age range was approx. 26.6 months. The breed distribution among the cases was: Golden Retriever (n=5), German Shepherd (n=2), Rottweiler (n=4), Kangal (n=3), Labrador Retriever (n=5), Mixed Breed (n=4), Alabay (n=1), Chow Chow (n=1), Border Collie (n=2), Samoyed (n=1), and Bulgarian Shepherd (n=2). About 57% of the cases had bilateral hip dysplasia, 37% had coxarthrosis, 3% had hip luxation, and 3% had excisional arthroplasty findings. In our study, both porous and non-porous screw cups and stems of the Innoplant brand were used, while complications occurred in 10 cases. Two of these complications happened during the operation, while 8 occurred after the operation. Of these complications, 9 were classified as major, and 1 was classified as minor. The complications observed including femoral fractures (n=2), stem subsidence (n=3), stem loosening (n=1), cup loosening (n=2), cup dislocation (n=1), and loosening in both the stem and the cup (n=1). In 4 of these cases, the prosthesis was completely removed, while revision surgery was performed in 6 dogs. The long-term results of the 6 revised cases were evaluated as very good. The time until the patients could place their foot on the ground after the operation was 24 hours for 11 cases and 36 hours for 20 cases. In conclusion, the cementless Innoplant prosthesis system used for THR, is a viable prosthetic technique with a low complication rate which provides successful clinical and radiographic outcomes over an average period of 31 months.

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INTRODUCTION

Arthritis in dogs mostly appears in the hip joint. Osteoarthritis is observed in 20% of adult dogs and 80% of geriatric dogs (Özaydın *et al.,* 2003; Eginton and Gordon_evans, 2024). Additionally, a study reported that 90% of dislocations in dogs occur in the hip joint (McLaughlin, 1995). Severe degenerative changes in the coxofemoral joint are treated with femoral head ostectomy (excisional arthroplasty) or total hip replacement. Femoral head and neck ostectomy (FHNO) are relatively simple and cost-effective techniques (Gibson *et al.,* 1991; Kılıç *et al.,* 2002; Harper, 2017). However, due to postoperative complications such as limb shortening, abnormal gait, muscle atrophy, decreased range of motion, and persistent lameness, the use of hip prosthetics is increasing worldwide (Decamp *et al.,* 2016; Guiot and Dejardin, 2018; Ober *et al.*, 2018).

Total Hip Replacement (THR) was first introduced in veterinary medicine in 1974, initially using cemented, fixed-head femoral components made of stainless steel and acetabular cups made of polyethylene, produced in three different sizes (Hoefle, 1974). The most common indication for Total Hip Replacement is secondary coxofemoral osteoarthritis due to hip dysplasia. Other indications for hip replacement include irreparable acetabular fractures, femoral head-neck fractures, coxofemoral luxations secondary to hip dysplasia, and avascular necrosis of the femoral head (Gifford *et al.,* 2020; Allaith *et al.,* 2023; Huels *et al.,* 2024). Additionally, it has been used to salvage limbs in cases of acetabular and proximal femur tumors to avoid amputation (Fitzpatrick *et al.,* 2012; Gemmill *et al.,* 2012; Vezzoni and Peck, 2018).

Currently, three types of hip prostheses are used in dogs: cemented, cementless, and hybrid. After hip prosthesis surgery, it typically takes dogs between 6 to 12 weeks to start using their leg again (Nelson *et al.,* 2007; Ireifej *et al.,* 2012). The complication rate following Total Hip Replacement (THR) ranges from 4-33%. The most common complications are femoral cracks/fractures, infection, loosening of the acetabular cup, and subsidence of the femoral stem (Nelson *et al.,* 2007; Guerrero and Montavon, 2009; Ganz *et al.,* 2010; Ozsoy *et al.,* 2011; Vezzoni *et al.,* 2015; Kidd *et al.,* 2016; Mitchell *et al.,* 2020; Kwok and Wendelburg, 2023; Thibault and Haudiquet, 2023).

The aim of this study was to evaluate the clinical and long-term results of the use of Innoplant brand hip prostheses in various sizes of cementless, porous and nonporous structures in 30 dogs with hip dysplasia, and to investigate the late loosening and infection with control radiographs.

MATERIALS AND METHODS

Ethical Statement: This study was approved by the Istanbul UniversityCerrahpaşa, Faculty of Veterinary Medicine Animal Experiments Ethics Committee (Approval no: 2024/46).

Animals: The study included 30 dogs of various breeds weighing between 30-60 kg that underwent Total Hip Replacement with Innoplant brand prostheses from May 2015 to June 2023.

Preoperative Assessment and Preparation: Dogs presenting with lameness related to the hip joint underwent orthopedic examination. Under sedation, the coxofemoral joint was assessed for luxation, and Ortolani signs were evaluated in dogs younger than 1 year. Whereas, for dogs showing pain response during joint movement, detected luxation, and positive Ortolani signs, radiographs were taken of the hip joint in lateral, symmetrical ventrodorsal positions. Dogs with radiographic signs of osteoarthritis were identified femoral head fractures, or classified as dysplastic according to Orthopedic Foundation for Animals (OFA) criteria and recommended for total hip replacement. Preoperative measurements were taken for dogs accepting the total hip replacement.

Dogs weighing less than 20 kg (n=10), those with skin lesions and chronic cystitis (n=8), or those whose owners did not agree to follow the study protocol (n=16), including post-operative care and follow-up examinations, were excluded from the study.

Preoperative Radiological Assessment: A 1:1 scale template from the Innoplant company was used to determine the size of the prosthetic components on digital radiographs. The measurements of the acetabular cup and femoral component obtained from the scale template were recorded for each dog. Additionally, based on Silveira *et al.,* 2022, the classification of medialization of the greater trochanter was performed.

Anesthesia Protocol: Thirty minutes before the operation, a combination of 25 mg/kg of Cefazolin (Sefazol, Mustafa Nevzat) and 2 mg/kg of Gentamicin (Genta, IE Ulagay) was administered intravenously, and Cefazolin was continued every 2 hours throughout the surgery. For premedication, Medetomidine (Domitor, Zoetis) and Butorphanol (Butomidor, Ritcher pharma) were used. After induction with Propofol (Pofol) Fresenius), the endotracheal intubation was performed according to the size of the trachea, while anesthesia was maintained with 2% Isoflurane (İsoflurane, Adeka).

Surgical Preparation: After shaving and disinfecting the area (with chlorhexidine), the patient was positioned laterally with the surgical side facing up. The medial sagittal plane of the pelvis was aligned parallel to the dorsal spinous processes for the operation. To ensure and maintain this ideal positioning throughout the surgery, the patient was placed on a specially designed universal hip navigation device. This navigation device ensured that the pelvis remained stationary, allowing the retroversion apparatus to properly prepare the acetabular bed at the appropriate angle.

Approach and Implant Placement: An incision approximately 4-5 cm long was made in the skin craniolaterally to the greater trochanter, extending towards the proximal ilium. After dissection of the subcutaneous and connective tissues, an incision was made in the fascia lata. A partial tenotomy of the gluteus profundus tendon was performed to access the hip joint. A longitudinal incision was made in the joint capsule. The femoral head was laterally deviated. The femoral head and neck were resected using an oscillating saw from the greater to the lesser trochanter (Kennet, 2014).

Next, the acetabular bed was reamed starting with the smallest diameter reamer (22 mm) and was progressively reamed to match the dimensions of the acetabulum as measured on radiographs. Reaming continued until reaching the subchondral bone. The selected acetabular cup was then positioned in the acetabulum with normal inclination (45-55 degrees) and retroversion (20-25 degrees) using a retroversion navigator. Similarly, the femoral stem and head were reamed from the smallest size up to the desired dimensions. A stem of the appropriate size for the medullary canal of the femur was placed (Olmsted *et al.,* 1981). The joint capsule was closed as completely as possible, and the subcutaneous tissue and skin were sutured in accordance with surgical protocols (Kennet, 2014).

Radiographic Follow-Up: Ventrodorsal and mediolateral radiographs were taken immediately after surgery, on the 10th day, 30th day, 180th day, 12 months, and then annually. In the VD and ML projections, the position of the stem and cup, stem subsidence, periosteal and cortical bone changes, and the appearance of radiolucent lines between the implant and bone were recorded and compared between examinations. A stable cup and stem were indicated by the absence (or very rare occurrence) of radiolucent lines. Aseptic loosening was identified by the presence of radiolucent lines. The presence or absence of other complications was determined from the radiographs.

The radiographic follow-up period (average and range) and the duration of the surgery were recorded.

Postoperative Care and Patient Follow-Up

For 5 days after surgery, Cefazolin was administered intramuscularly at a dose of 25 mg/kg twice daily, and Gentamicin was given at a dose of 2 mg/kg. Meloxicam (0.2 mg/kg) and Butomidor (0.04 mg/kg) were administered for 3 days.

The animals were routinely discharged 4-6 days after the operation. Owners were advised to restrict movement in a confined area for 6 weeks following surgery and to use a leash outdoors to prevent jumping and unsupervised activities. During routine follow-up visits, the dogs' gait and radiographs were monitored and recorded. Lameness scoring was performed on day 90 with a score between 0 and 5 as modified from Car and Dycus, 2016 (Table 1).

Table 1: Lameness grading Scale

Grade	Scoring Criteria
0	Normal, no lameness
1	Mild lameness
2	Obvious weight-bearing lameness
3	Severe weight-bearing lameness
4	Intermittent non-weight-bearing lameness
5	Non- weight-bearing lameness

RESULTS

From January 2018 to March 2023, a total of 33 Total Hip Replacements (THR) were performed using the Innoplant cementless total hip system by the same surgeons. The study included 30 dogs, comprising 19 males and 11 females, with 3 dogs undergoing bilateral THR. The average body weight was 33.05 kg (range: 14–58 kg) and the average age was 26.6 months (range: 9–108 months). The breed distribution in the study was as follows: Golden Retriever (n=5), German Shepherd (n=2), Rottweiler (n=4), Kangal (n=3), Labrador Retriever (n=5), Mixed breed (n=4), Alabai (n=1), Chow Chow (n=1), Border Collie (n=2), Samoyed (n=1), and Bulgarian Shepherd (n=2) (Table 2). Almost 57% of the cases had bilateral hip dysplasia, 37% had coxarthrosis, 3% had hip luxation, and 3% had excisional arthroplasty findings. None of the patients responded to medical treatment.

From the preoperative radiographs, the medialization classification, which evaluates the morphological position of the greater trochanter relative to the femoral medullary canal, revealed that 10 cases were classified as grade 1, 18 cases as grade 2, and 5 cases as grade 3.

The average duration of the surgeries was 171.8 minutes, with a range of 135 to 220 minutes. Cultures were taken from all patients using a swab during the surgery, and no growth was detected. In the study, Innoplant THR materials included non-porous cups and stems (n=21) and porous cups and stems (n=12). The diameters of the acetabular cups used were 22 mm (n=6), 24 mm (n=9), 26 mm (n=8), 28 mm (n=7), and 32 mm (n=3). Head sizes were 18 mm (n=29) and 15 mm (n=4), with short neck (S) used in 6 cases, medium neck (M) in 11 cases, long neck (L) in 10 cases, and extra-long neck (XL) in 6 cases. The stem sizes used were #4 (n=1), #5 (n=3), #6 (n=5), #7 (n=7), #7.5 (n=2), #8 (n=5), #9 (n=7), and #10 (n=3) (Table 3) (Fig. 1).

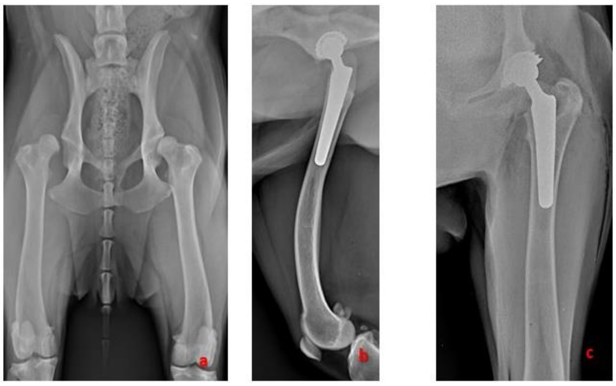

Fig. 1: Preopertive Ventrodorsal (a), postoperative Laterolateral (b) and Ventrpdprsa; (c) radiopraphic of Case 6.

Complications occurred in 10 cases. Two of these complications were observed during the operation, while 8 were noted postoperatively. Among these complications, 9 were classified as major and 1 as minor. The complications including femoral fractures (n=2), stem subsidence (n=3), stem loosening (n=1), cup loosening (n=2), cup luxation (n=1), and both stem and cup loosening (n=1) were observed (Table 4).

In cases with intraoperative femoral fractures (case 9 with porous, case 27 with non-porous stems), fixation was achieved using a 1 mm thick cerclage wire. Owners were advised to confine the patient to a cage for 4-6 weeks postoperatively. While case 9 healed without issues, in case 27, despite signs of healing at the fracture site on the 45-day follow-up radiographs, stem loosening was detected. Since the owner did not agree to a revision surgery, the prosthesis was removed without performing a revision.

Acetabular cup luxation occurred in case 23 (non-porous) one week after surgery. Due to the chronic nature of this case and severe muscle atrophy, the prosthesis was removed. Aseptic cup loosening was observed in two cases (cases 7 and 24). In case 24, excessive periosteal reaction developed two months after surgery due to loosening, leading to the removal of the cup and all prosthesis components. Three months after the prosthesis removal, radiographic signs of the reaction had resolved, but the owner declined a second prosthesis surgery. Although a revision was recommended, the owner refused, resulting in complete removal of the prosthesis. In case 7, aseptic cup loosening was detected 6 months after surgery. The acetabular cup was removed and revised with a cemented cup size 25, and the patient healed without complications (Fig. 2).

Stem subsidence occurred in 3 cases (cases 30, 10, and 8). In case 8, a porous stem was used, while non-porous stems were used in the other two cases. In case 8, the owner reported that the patient was excessively active and that restriction of movement in the prosthetic area was not enforced. On the 30th day postoperatively, controls revealed 3 mm of subsidence and subsequent craniodorsal hip luxation. In this case, the femoral head was revised and replaced with a longer head (XXL). Subsequent follow-up showed no further complications.

In case 30, 1.8 mm of subsidence was detected in the stem on the 25th day after surgery. In case 10, 2 mm of subsidence was observed on the 40th day postoperatively.

Table 2: General information about total hip replacement cases

Case	Breed	Age	Sex	BW	Leg	Radiography	TMM	Follow up
1	Golden Retriever	11,5 m	F	27 kg	R	BHD	G 3	48 m
2	Border Collie	11 m	F	31 kg	BL	BHD	G 2	60 m
3	Labrador Retriever	12 m	M	35,5 kg	L	Coxartroz	G 3	50 m
4	Kangal	9 m	M	52 kg	R	BHD	G 3	36 m
5	Border Collie	3 y	M	26 kg	R	Akut Hip luxation	G 2	28 m
6	Golden Retriever	18 m	F	29 kg	L	BHD	G 1	18 m
7	German Shepherd	9 m	F	19 kg	R	Bilateral Coxartroz	G 3	38 m
8	Kangal	16 m	M	58 kg	R	BHD	G 4	-
9	Labrador Retriever	9 y	M	40 kg	BL	Bilateral Coxartroz	G 3	35 m
10	German Shepherd	2.5 y	M	45 kg	L	Bilateral Coxartroz	G 3	50 m
11	Chow Chow	5 y	M	18 kg	L	Left Coxartroz	G 3	34 m
12	Rotweiler	2.5 y	F	35 kg	R	Bilateral Coxartroz	G 3	16 m
13	Rotweiler	12 m	M	22 kg	L	BHD	G 2	54 m
14	Labrador Retriever	12 m	M	28 kg	L	BHD	G 3	60 m
15	Mixed Breed	48 m	M	14 kg	R	FHNO surgery	-	18 m
16	Alabay	10 m	M	48 kg	L	BHD	G 2	22m
17	Labrador Retriever	2 y	M	35 kg	R	BHD	G 3	20m
18	Kangal	1.5 y	M	57 kg	L	BHD	G 3	22m
19	Golden Retriever	14 m	F	29 kg	R	BHD	G 3	-
20	Mixed Breed	18 m	M	25 kg	L	BHD	G 2	60m
21	Mixed Breed	3 y	M	27 kg	L	L Coxartroz	G 4	38m
22	Labrador Retriever	6 y	F	32 kg	R	Bilateral Coxartroz	G 3	20m
23	Bulgarian Shepherd	3 y	M	28 kg	R	R Coxartroz	G 3	-
24	Rotweiler	2 y	F	40 kg	L	BHD	G 4	-
25	Golden Retriever	16 m	M	33kg	R	BHD	G 2	12m
26	Rotweiler	14 m	M	45 kg	L	BHD	G 1	31m
27	Samoyed	12 m	M	25 kg	L	BHD	G 1	-
28	Golden Retriever	11 m	F	29 kg	BL	BHD	G 3	38m
29	Mixed Breed	5 y	F	21 kg	L	L Coxartroz	G 2	45m
30	Bulgarian Shepherd	16 m	F	38 kg	R	Bilateral coxartroz	G 4	60m

Table 3: Characteristics of the Innoplant prosthesis used in the operation

Case	Op Duration	Stem	Cup	Head	Lamenes Score
1	150 min	#5 P +	22mm P+	18- M	0
2	165 min	7 P+	24mm P+	18- M/L	1
3	165 min	#9 P-	26mm P-	18- S	0
4	180 min	#10 P-	32 mm P-	18-S	1
5	135 min	#6 P+	22mm P+	15-S	0
6	135 min	#7 P+	24mm P+	18-M	0
7	165 min	#6 P-	24mm P-	18-M	2
8	180 min	#9 P+	32mm P+	18-XL	-
9	195 min	#8 P+	28mm P+	18-XL	2
10	150 min	#9 P-	28mm P-	18-M	1
11	175 min	#5 P-	22mm P-	15-L	0
12	190 min	#8 P-	28mm P-	18-XL	4
13	160 min	#5 P-	22m P-	15-XL	2
14	190 min	#7 P+	26mm P+	18-M	0
15	180 min	#4 P+	22mm P+	15-L	0
16	140 min	#9 P-	28mm P-	18-L	2
17	150 min	#9 P-	26mm P-	18-L	2
18	170 min	#10 P-	32mm P-	18-S	1
19	180 min	#7 P-	26mm P-	18-M	-
20	180 min	#6 P-	24mm P-	18-M	3
21	150 min	#6 P-	24mm P-	18-L	3
22	170 min	#8 P+	26mm P+	18-L	2
23	210 min	#7 P-	24mm P-	18-L	-
24	170 min	#9 P-	26mm P-	18-L	-
25	220 min	#8 P-	26mm P-	18-L	4
26	180 min	#10 P+	28mm +	18-S	2
27	140 min	#7 P-	24mm P-	18-S	-
28	190 min	#7.5 P-	24, 26mm P-	18-M	2
29	210 min	#6 P+	22mm P+	18-M	1
30	180 min	#9 P-	28mm P-	18XL	2

Min: minutes, P+: porous, P-: non porous , S:small, M:medium, L: large, XL: extra large.

Table 4: Complications in prosthesis cases

Case Number	Complication
7	Asetabular Cup loosing
8	Stem subsidence
9	Femoral fissure
10	Stem subsidence
19	Stem+ Cup loosing
23	Cup luxation
24	Cup loosing
27	Femoral Fissure
30	Stem subsidence

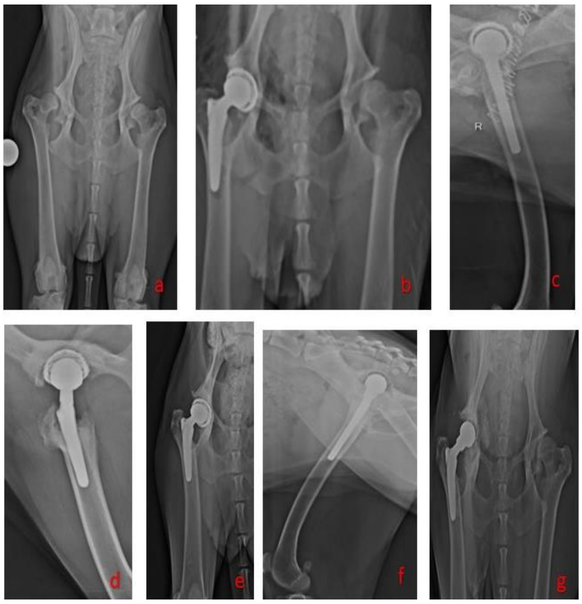

Fig. 2: preoperative VD (a), postoperative VD (b) and LL (c) view of case 7. Appearance of eseptic cup loosening complication 6 months after the first operation (d,e). LL(f) and VD (g) appearance after removal and replacement with a cemented cup.

In both cases, the femoral head was removed and replaced with an XXL head. The luxation between the acetabulum and the head was resolved while the dog was healed without complications.

Aseptic loosening of both the stem and cup was detected in one case (case 19, non-porous) on the 50th day postoperatively. Due to the owner's refusal, a revision could not be performed, and the prosthesis was removed. Stem loosening was identified in another case (case 25, non-porous) on the 120th day. The stem was removed and revised with a cemented size 9 stem. Follow-up evaluations showed no further issues with the patient.

Revision surgery was performed in 6 cases, while the prosthesis was completely removed in 4 cases. All 6 cases that underwent revision healed without issues and had excellent long-term gait outcomes. In the 3 cases that received bilateral total hip replacements, no complications were encountered. Complications were categorized based on their occurrence: 9 were considered short-term (3-6 months) and 1 as medium-term (6-12 months). No long-term complications were observed in our study. During long-term clinical follow-ups, 29 of the 33 cases (including 3 bilateral cases) showed no problems with gait. The remaining 4 cases, in which the prosthesis was removed, these were not included in the long-term follow-up evaluations.

After surgery, the time until patients placed their foot on the ground was 24 hours for 11 cases and 36 hours for 20 cases. Two cases that developed fractures during the operation were excluded from this assessment as they were kept in cage rest for 3 weeks.On the 90th day postoperatively, lameness scoring was performed during clinical examinations. According to this classification, 7 cases had a score of 0, 5 cases had a score of 1, 9 cases had a score of 2, 2 cases had score of 3 and 2 cases had a score of 4. The average clinical and radiological follow-up duration for the dogs was 31 months, with a range of 12 to 60 months; these follow-ups were available for 26 of the 30 dogs. Follow-up was not possible for 4 dogs due to prosthesis removal.

DISCUSSION

In this study, we shared the clinical and radiographic outcomes of the Innoplant THR in 30 dogs and 33 cases, with an average follow-up period of 31 months. Gifford *et al.,* (2020) evaluated lameness over an average of 26.5 months in 11 dogs and found that the walking ability of 6 of these dogs was assessed as good or very good. According to the clinical lameness evaluation performed on the 90th day post-THR, we achieved successful walking results ranging from excellent to good in 26 of the dogs.

Denny *et al.* (2018) reported an 87% success rate in 55 cases of cementless prostheses applied to 50 dogs over a 5-year period. In our study, the success rate was 88% over a follow-up period ranging from 12 to 60 months (average 31 months) in 33 cases. Our success rate was affected by the fact that 4 cases could not undergo revision due to the owners' refusal.

Complications arising after Total Hip Replacement (THR) include hip joint dislocation, infection, incorrect placement of prosthetic components, septic/aseptic loosening of the cup and stem, femoral cortex cracks and fractures, sciatic nerve injury, and stem subsidence (Hummel *et al.,* 2010; Vezzoni *et al.,* 2015; Kang *et al.,* 2022; Zuendt *et al*., 2023). In a study by Roe and Macellan-Little (2010) using the Biomedtrix THR system in 204 dogs, major complications were reported at 11%, with minor complications at 25%. The major complications included femoral fractures (4.4%), sciatic neuropathy, and cup loosening. Hach and Delfs (2009) reported complications following HELICA-type prosthesis application in 40 dogs, including bone resorption at the segmented collar area of the stem (5%), sciatic nerve injury (2.5%), femoral cortex cracks during stem placement (2.5%), femoral neck fractures (2.5%), acetabular cup loosening (10%), and stem loosening (2.5%). In our study, we identified 28% major complications and 3% minor complications. The complications observed were subsidence (10%), femoral cracks (3%), dislocation (3%), stem loosening (3%), cup loosening (13%), and implant failure (12%). No infections were observed in any of our cases postoperatively. The absence of infections in our cases is attributed to the preoperative measures including UV sterilization of the operating room, preoperative bathing of patients with chlorhexidine, and IV antibiotic therapy administered 30 minutes before and during the operation at 2-hour intervals.

In THR applications, it is generally accepted that osteointegration occurs more rapidly in young dogs (Bergh and Budsberg, 2014; Lanz *et al.,* 2021). Therefore, it is expected that both aseptic loosening of the screw cup and subsidence complications in the femoral stem would be less frequent. In our study, 57% of our cases were under 2 years of age, and we believe this may have contributed to the lower incidence of loosening and subsidence complications observed.

The primary goal of acetabular reaming in hip prosthesis surgery is to remove sclerotic bone and reach spongy bone. In ideal reaming procedures, the porous cup integrates smoothly with the acetabulum. In older dogs and those with severe coxarthrosis, increased sclerotic bone and decreased spongy bone can lead to thinning of the acetabular floor (Harper, 2017). In our study, one case experienced medial wall collapse during acetabular preparation. The remaining spongy bone was augmented with autograft, and the screw cup was successfully placed and healed without complications. Based on these experiences, we believe that using autografts in cases where excessive thinning or collapse occurs during acetabular preparation may reduce the likelihood of complications.

The placement of the acetabular cup is recommended to have a 45-degree inclination and 15-20 degree retroversion angle (Olmsted *et al.,* 1981). In one case, craniodorsal luxation was developed in our study. We associated the craniodorsal luxation with the inclination angle being set greater than 45 degrees intraoperatively.

Early postoperative subsidence in cases where femoral rasping is insufficient and the endosteum is not reached has been reported (vezzoni and Peck, 2018). We observed subsidence complications in two of our cases. This was attributed to the oversized breeds of the patients and the use of a size 10 stem that was small for the cavity. We believe that in large breeds with wide medullary cavities, using a threaded stem could address the subsidence issue.

The anatomical structure of the greater trochanter and its positioning on the medullary canal (medialization) directly affects the ideal reaming of the femoral canal and the optimal positioning of the stem in the canal. In cases of grade 1 and 2 medialization, the medial and lateral cortices of the femur can be thinned to the desired levels. In cases of medialization grade 3 or higher, thinning may be more pronounced at the lateral and cranial edges during reaming, potentially leading to fractures and cracks in the femur during stem placement (Silveira *et al.,* 2022). In our study, AP radiographs immediately after surgery showed that the stem was not perfectly parallel to the medullary cavity and was more reliant on the medial cortex in X cases. Additionally, femoral cracks occurred in two cases during reaming, which were stabilized with cerclage wire. One case healed without issues. We attribute these complications to the high grade of trochanter medialization, which led to uneven reaming. To prevent fractures in high-grade cases, it is important to avoid excessive removal of medullary cavity tissue from the lateral and cranial cortices, allowing the stem to be placed more smoothly and parallel to the medullary cavity.

Limitations of our study include a small sample size and the lack of objective analysis techniques, such as gait analysis, in evaluating limb use. Future studies with newer generations of InnoPlant THR systems, including gait analysis and larger sample sizes, will provide more scientific data on the efficacy of the InnoPlant prosthesis.

Conclusions: This study demonstrated that the cementless InnoPlant prosthesis system is a viable prosthetic model that provides successful clinical and radiographic results with a low complication rate over an average follow-up period of 31 months. Comparing the hydroxy apatate coated and laser sintering techniques used in human medicine with porous prostheses, the loosening rate of porous prostheses is lower. There are not many companies producing prostheses in the veterinary field, especially there are only one or two companies that we know of that produce new prostheses with laser sintering technique (Kyon and Innoplant). Therefore, the other important emphasis of our study is that the production of prosthetic implants with the latest technology (laser sintering) techniques by more veterinary companies will result in less material-related complication rates.

Conflict of interest: The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the study.

Data availability statement: The data that support the findings of this study can be requested from the corresponding author.

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Authors contributions: ZM, YA and SSH performed the operations and designed the study. YA, CNG and EBB collected the data. All authors contributed to the critical revision of the manuscript and read and approved the final version.

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