Journal of the Hellenic Veterinary Medical Society

Vol 76, No 3 (2025)

Prognostic factors associated with femoral head and neck excision outcomes in 108 dogs. A retrospective study

AA Krystalli, AI Sideri, G Kazakos, SK Papaefthymiou, I Savvas, AA Anatolitou, NN Prassinos

doi: [10.12681/jhvms.40194](https://doi.org/10.12681/jhvms.40194)

To cite this article:

Krystalli, A., Sideri, A., Kazakos, G., Papaefthymiou, S., Savvas, I., Anatolitou, A., & Prassinos, N. (2025). Prognostic factors associated with femoral head and neck excision outcomes in 108 dogs. A retrospective study. *Journal of the Hellenic Veterinary Medical Society*, *76*(3), 9851–9862. https://doi.org/10.12681/jhvms.40194

J HELLENIC VET MED SOC 2025, 76 (3): 9851-9862
ΠΕΚΕ 2025, 76 (3): 9851-9862

Retrospective study
Αναδρομική μελέτη

Prognostic factors associated with femoral head and neck excision outcomes in 108 dogs. A retrospective study.

A.A. Krystalli,[1] A.I. Sideri,[2] G. Kazakos,[1] S.K. Papaefthymiou,[1] I Savvas,[3] A.A. Anatolitou,[4] N.N. Prassinos[1]

[1]Surgery & Obstetrics Unit, Companion Animal Clinic, School of Veterinary Medicine, Faculty of Health Sciences, Aristotle University, Thessaloniki, Greece

[2]Clinic of Surgery, Faculty of Veterinary Science, School of Health Sciences, University of Thessaly, Karditsa, Greece

[3]Anesthesia and Intensive Care Unit, Companion Animal Clinic, School of Veterinary Medicine, Faculty of Health Sciences, Aristotle University, Thessaloniki, Greece

[4]Myrtidiotissis 8, Athens, Greece

ABSTRACT: Femoral head and neck excision (FHNE) is a simple and non-reversible surgical procedure in which the entire femoral head and part of the femoral neck are removed obliquely. This allows the formation of a functional pseudarthrosis providing pain relief for dogs suffering from severe hip-joint disease. However, the factors affecting surgery's outcome are controversial.

This study included 108 client-owned dogs. Every dog underwent a physical, orthopaedic, and radiological examination. Postoperatively, each dog owner answered a dog-mobility questionnaire. The association between quantitative variables and parameters was examined by statistical analysis.

The results show that the final weight-bearing time of the limb is negatively affected by the chronicity of the disease, while age and body weight do not affect it. No positive correlation was found in regard to the limitation of activity, administration of analgesia, and performance of physical therapy.

A dog's age and body weight, postoperative activity restriction, physical therapy, and the administration of analgesics do not affect the outcome of FHNE. The disease's chronicity and, consequently, muscle atrophy negatively affect the progress after surgery.

Keyword: Dog; femoral head and neck ostectomy; lameness.

Correspondence author:
A.A. Krystalli,
Surgery & Obstetrics Unit, Companion Animal Clinic, School of Veterinary Medicine, Faculty of Health Sciences, Aristotle University, Thessaloniki, Greece
E-mail address: akrystall@vet.auth.gr

Date of initial submission: **27-1-2025**
Date of acceptance: **20-2-2025**

INTRODUCTION

Coxofemoral conditions have a high prevalence in dogs, and there are several options for their treatment (Piermattei et al., 2006; Eyarefe et al., 2016; Engstig et al., 2022). Total hip replacement has been accepted as a surgical approach for a variety of conditions, while juvenile pubic symphysiodesis and double or triple pelvic osteotomy are solutions for dogs younger than one year old with hip dysplasia. Femoral head and neck excision (FHNE) is a commonly performed surgical procedure for the diseased coxofemoral joint (Peycke, 2011; Prostredny, 2014; Harper, 2017).

FHNE was originally introduced in orthopaedics by Girdlestone for the treatment of tuberculosis and septic arthritis of the hip in human medicine (Girdlestone, 1928, Girdlestone, 1943). It was quickly accepted by veterinary surgeons for the painful hip joint in dogs and cats. FHNE is indicated for disorders such as hip dysplasia, avascular necrosis of the femoral head (ANFH), osteoarthritis of the coxofemoral joint, comminuted acetabular or femoral neck fractures, fractures of the femoral head, chronic or non-reducible hip luxation, and failed total hip arthroplasty (Duff and Campbell 1978; Berzon et al., 1980; Roush, 2012).

During FHNE, the femoral head and neck are removed by an ostectomy at the junction of the femoral neck and metaphysis just medial to the greater trochanter without including the lesser trochanter. The aim of this resection is to limit bony contact between the femoral head and acetabulum, allowing the formation of a fibrous pseudoarthrosis lined by a synovial membrane (Prostredny, 2014; Krystalli et al., 2023). As the surgery's result is irreversible, it is considered as a "salvage" procedure (Piermattei et al., 2006; Eyarefe et al., 2016; Engstig et al., 2022). Some of the complications associated with FHNE are shortening of the limb, muscle atrophy, patellar luxation, damage to the sciatic nerve or its entrapment, decreased range of motion of the hip, continued lameness, and reduced exercise endurance (Berzon et al., 1980; Rawson et al., 2005; Off and Matis, 2010).

According to previous studies, the outcome of FHNE seems to be highly variable and is influenced by several factors, such as surgical technique, patient-related characteristics, and postoperative care (Off and Matis, 2010; Schulz and Dejardin, 2003; O'Donnell et al., 2015). Surgical factors include atraumatic soft tissue handling during the surgical approach, sufficient resection of the femoral neck, and a smooth resected surface. Deep gluteal and biceps femoris muscle slings have been developed to prevent bony contact between the pelvis and femur, and some surgeons suggest capsulorrhaphy and resection of the lesser trochanter as well (Bjorling and Chambers, 1986; Lewis, 1992; Dueland et al., 1997;Off and Matis, 2010).

The patient's weight and age and the disorder's chronicity are also considered to affect the prognosis (Denny and Butterworth, 2000; Harasen, 2004; Fattahian et al., 2012). Postoperatively, controlled exercise, appropriate analgesic administration, and early physical therapy contribute to the success of the procedure (Duff and Campbell, 1977; Piek, 1996; Schulz and Dejardin, 2003; Anderson, 2011). However, most information in literature is usually contradictory because of confounding factors, including the owners' subjective views of outcomes, lack of objective criteria, and differences in postoperative physical therapy (Harper, 2017).

The object of this retrospective study was to examine the perioperative parameters that influence the outcome of the postoperative gait of patients (age, body weight, disease that necessitated FHNE and its chronicity, physical therapy, and controlled physical activity postoperatively). We hypothesized that the limb's time to weight-bearing postoperatively is affected by the chronicity of the disease, postoperative physical therapy, administration of analgesics, and controlled activity and that it is not affected by the age and body weight of the patient.

MATERIALS AND METHODS

The study retrospectively examined clinical records of client-owned dogs that presented to the Surgery and Obstetrics Unit at the Companion Animal Clinic, Department of Veterinary Medicine, Aristotle University of Thessaloniki, Greece, and were subjected to FHNE because of coxofemoral diseases between September 2006 and July 2017. Each dog owner answered a dog-mobility questionnaire (Table 1) to provide additional data about the patients.

The initial examination included the recording of the history of the dog (its nature, occurrence and type of lameness, physical activity, presence of pain, and type and quantity of food), along with a physical and orthopedic examination and gait evaluation based on a six-grade scale (Table 2). Ventrodorsal and lateral radiographs of the coxofemoral joints were taken during the initial examination while the dogs were under general anesthesia.

Table 1. Questionnaire

A/A:.........................
Registration number:...
Presentation date:.................. **Surgery's date:**................
Owner:...
Phone number:...
Dog's characteristics: Male ☐ Female ☐ Neutered☐
Age:...............................Breed:............................
Name:...............................Weight:..........................

Disease:
Hip luxation ☐
Avascular necrosis of the femoral head ☐
Fracture of Femoral Head ☐
Hip Dysplasia
Fracture of the Acetabulum ☐
Hip Osteoarthritis ☐

Completed questionnaire: Yes☐ No ☐

1. Preoperative lameness
1.1 Duration:........................
1.2 Grade: ⓪ ① ② ③ ④ ⑤
2. Postoperative lameness
2.1 When did the dog's limb begin to weight-bearing?
2.2 When did the limb exhibit full weight bearing?
1.3 Lameness grade 3 years postoperatively ⓪ ① ② ③ ④ ⑤
3. Postoperative analgesia
3.1 Yes ☐ No
1.2 Administration's duration:.................................
3.3 Was analgesia useful? Yes ☐ No ☐ Possibly ☐
4. Postoperative restriction
4.1 Yes No ☐
4.2 Duration:.................
4.3 Restriction's kind:........................
1.4 Was restriction useful? Yes ☐ No ☐ Possibly ☐
5. Physical therapy
5.1 Yes ☐ No
5.2 Kind: Passive movements ☐ Swimming ☐ Bathtub ☐
5.3 Frequency:...............................
5.4 Duration:..........................
5.5 Was analgesia beneficial? Yes ☐ No ☐ Maybe ☐
6. Does the dog appear lame after exercise?
6.1 Yes ☐ No
6.2 Grade: ⓪ ① ② ③ ④ ⑤
6.3 Does the lameness reduce after rest? Yes ☐ No ☐
7. Assessment of dog's postoperative clinical condition
1. Worsening ☐
2. Stable ☐
3. Small improvement ☐
4. Great improvement ☐
5. Full recovery ☐

8. Other questions
8.1 Do you think that your dog's quality of life is the same as before?
....
8.2 If you could decide again, would you make the same decision?
....

Table 1. Questionnaire

8.3 Would you recommend this treatment to someone you know for their dog?
……………………………………………………………………………………………

9. Differences in dog behavior/activity after surgery

Behavior/Activity	Reduction	Stable	Increase	I don't know
9.1 Activity grade	☐	☐	☐	☐
9.2 Movement speed	☐	☐	☐	☐
9.3 In the mood for playing	☐	☐	☐	☐
9.4 Physical condition	☐	☐	☐	☐
9.5 Mood	☐	☐	☐	☐
9.6 Friendly attitude towards people	☐	☐	☐	☐
9.7 Friendly attitude towards other animals	☐	☐	☐	☐
9.8 Endurance	☐	☐	☐	☐

Table 2. Lameness scale (Krystalli et al. 2023)

Degree of Lameness	Limb 's Weight-Bearing				Characterization of Lameness
	Description	Stance	Walk	Run	
0	Full (normal) weight-bearing	……	……	……	Absence
1	Partial weight-bearing: hardly visible	……	……	……	Light
2	Partial weight-bearing: easily visible	……	……	……	Mild
3	No weight-bearing: intermittent, sporadic (≤1:5) *	……	……	……	Moderate
4	No weight-bearing: intermittent, frequent (>1:5) *	……	……	……	Severe
5	No weight-bearing: continuous	……	……	……	Not functional
Degree of lameness = (S + W + R)/3					

*: limb lift frequency per 5 steps

The criteria for inclusion of animals in the study were:

a) post-operative follow-up or communication with the owner for a period of ≥1 year from surgery
b) lameness of the affected limb due only to the coxofemoral disease that necessitated FHNE. Any other cause of lameness resulted in exclusion from the study (e.g., neurological disorder, osteoarthritis of stifle or tarsal joint) and
c) grade of the non-affected limbs' lameness ≤ 2/5 degrees.

A craniolateral approach to the hip was performed in all cases. After transection of the joint capsule and the round ligament, the limb was luxated and externally rotated by 90°. However, in some cases, the ligament was already torn. Osteotomy of the femoral neck was achieved using an osteotome, and any rough edges were removed with a rongeur or bone rasp (Piermattei et al. 2006; Harper 2017). All surgeries were led by the same surgeon.

The dogs were housed for one day in our clinic, where intravenous antimicrobial and analgesic drugs were given. In the postoperative period, non-steroidal anti-inflammatory drugs (NSAIDs) were administered for 7 to 10 days, based on the older analgesic strategy of administrating NSAIDs in order to encourage walking in only the initial postoperative period of the most intense pain. Significant limitation of physical activity (no running and jumping, short leashed walks) for 4 weeks and implementation of passive range-of-motion exercise until the limb's time of final weight-bearing were also advocated. The postoperative clinical evaluation of the operated limb was assessed using the six-grade scale (Table 2).

Two main parameters were used in this study. The first was the time of initial weight-bearing (TIWB) of the limb, which refers to the moment during the postoperative period of FHNE when the animal first begins using the limb, albeit with varying degrees of lameness (partial weight-bearing). TIWB was recorded by the owners as it is an objective parameter. The second was the time of final weight-bearing (TFWB) of the limb. TFWB signifies the moment in the postoperative period of FHNE (maximum follow-up period: 1 year) when the limb exhibits full weight-bearing or displays the least amount of lameness possible (partial weight-bearing), which remained unchanged until the study's completion. TFWB was recorded by the authors.

Dog owners answered a questionnaire (Table 1) by phone 36-155 months (mean: 73.3) postoperatively. The questionnaire comprised 15 questions related to compliance with post-operative instructions, the patient's current well-being and physical function, and the owner's satisfaction with the outcome. The owners were asked about the type and frequency of physical therapy, the method and duration of restraint of the dog, and the efficacy of the analgesic. In addition, the limb's TIWB, TFWB, and the grade of lameness after exercise were determined. Finally, the owners were asked to assess their dog's quality of life and progress, and to detect possible changes in its behavior.

STATISTICAL ANALYSIS

Data were summarized by calculating the absolute and relative frequencies (percentages), measures of central tendency (mean and median values), and measures of variance (minimum and maximum values and standard deviations). The association between quantitative variables and parameters was examined by evaluating the magnitude and statistical significance of Pearson's correlation coefficient r for linear covariation and Spearman's rank correlation coefficient *rho* (ρ) for general monotonic covariation. In all hypothesis-testing procedures, the significance level was predetermined at $a=0.05$ ($p \leq 0.05$). All statistical analyses were performed with the software IBM SPSS Statistics ver. 23.0.

RESULTS

From September 2006 to July 2017, the medical records of 182 cases that had undergone FHNE were obtained from the registry of the Companion Animal Clinic. Only 108 of them met the inclusion criteria of this study. In 23 cases, it was impossible to collect the required data because of dog owners' reluctance to answer the questions or because their phone number was not valid. In 51 cases, there were coexisting orthopedic disorders in the operated limb or other limbs.

Most of the 108 dogs were male (n=65, 60.2%) and non-neutered (n=97, 89.8%), while 43 were female (39.8%), and 11 were neutered (10.2%). Most dogs were of mixed breed (Table 3).

Age

The mean age of patients when the surgery was performed was 12 months. The youngest patient was 3 months old, and the oldest was 156 months old. No statistically significant correlation was detected between age and the limb's final weight-bearing by both Pearson's r test (r=-0.123, p=0.235) and Spearman's *rho* test (*rho*=-0.007, p=0.946).

Weight

The dogs' mean weight was 14.6 kg, with the lightest weighing 2.1 kg and the heaviest weighing 50 kg. Both Pearson's r test (r=0.018, p=0.860) and Spearman's *rho* test (*rho*=-0.144, p=0.164) did not detect a statistically significant correlation between body weight and TFWB of the operated limb.

Disease necessitating FHNE

Hip luxation (n=35, 32.4%) and ANFH (n=32, 28.7%) were the most frequent indications for FHNE (Table 4). Only between ANFH and the limb's TFWB showed a weak but statistically significant correlation according to Pearson's r (r=0.223, p=0.030) and Spearman's *rho* test (*rho*=0.238, p=0.020). ANFH correlated with increased TFWB.

Disease chronicity

The duration of pre-existing lameness ranged from 1 to 1800 days (mean 70.5, median 30). The preoperative gait evaluation showed grade 5 lameness in the majority of dogs (48 dogs, 44.4%), grade 3 lameness in 26 dogs (24.1%), grade 4 lameness in 17 dogs (15.7%), grade 2 lameness in 16 dogs (14.8%), and grade 1 lameness in one dog (0.9%). Both the Pearson test (r=0.346, p=0.001) and Spearman test (*rho*=0.388, p<0.001) revealed a delay in the limb's final weight-bearing as the duration of preoperative lameness increased.

Physical activity restriction

Physical activity restriction was applied to 94 dogs (87%). Table 5 shows the restriction type used by

Table 3. Distribution of dogs' breed submitted for femoral head and neck excision

Breed	Number of Dogs	*Percentage of Dogs (%)*
Mongrel	29	26.9
Yorkshire Terrier	13	12
Maltese	9	8.3
Pincher	7	6.5
German Shepherd Dog	6	5.6
Greek Harehound	4	3.7
Golden Retriever	4	3.7
Greek Shepherd	4	3.7
Poodle	3	2.8
Epagneul bretton	3	2.8
Pekingese	2	1.9
Jack Russell Terrier	2	1.9
Pointer	2	1.9
Pug	2	1.9
King Charles Spaniel	2	1.9
Kurzhaar	2	1.9
Setter	2	1.9
Rottweiler	2	1.9
American Pitbull	2	1.9
Jura Hound	1	0.9
Bullmastiff	1	0.9
Bullterrier	1	0.9
French Bulldog	1	0.9
Cane Corso	1	0.9
Fox Terrier	1	0.9
Chow-chow	1	0.9
Barak Hound	1	0.9
Total	108	100

dog owners. Some of them noticed that when they permitted their dogs to run, the lameness was worsened. In this context, restriction was considered to have contributed to the better outcome for 74 dogs (78.7%). Its effectiveness was not strongly supported in 18 cases (19.2%) and was considered useless in 2 cases (2.1%). Neither the Pearson analysis (r=-0.051, p=0.620) nor Spearman analysis (rho=0.023, p=0.823) detected any statistically significant correlation between the duration of restriction and the limb's TFWB.

Physical therapy

Recommended physical therapy was applied to 64 dogs (59.3%) and lasted between 7 and 730 days (mean 29.7, median 15, ± standard deviation 73.8). Owners used more than one type of physical therapy and observed that the early discontinuation of physiotherapy for one or more days led to stiffness, which subsided upon resumption. According to them physical therapy was assessed as effective for 53 dogs (82.8%), probably helpful for 9 dogs (14,1%), and not helpful for 2 dogs (3.1%). No statistically significant correlation was detected between the duration of physical therapy and the limb's TFWB by both Pearson's test (r=-0.043, p=0.681) and Spearman's test (rho=-0.068, p=0.514).

Analgesia

All dogs received postoperative analgesia, and according to the majority of owners, it was effective for 72 dogs (66.7%) and questionable for 24 dogs (22.2%). In 12 cases(11.1%) analgesia was considered as ineffective. The duration of analgesics administration was 7 to 10 days. Spearman's statistical test did not show any correlation between the duration of analgesia administration and the limb's final weight-bearing (rho=0.134, p=0.217). However, Pearson's r test showed a positive, weak, and

Table 4. Percentage distribution of orthopaedic conditions necessitating FHNE

Condition	Occurrence	Percentage distribution (%)
Hip luxation	35	32.4
Avascular necrosis of the femoral head	31	28.7
Fracture of Femoral Head	25	23.2
Hip Dysplasia	10	9.2
Fracture of the Acetabulum	4	3.7
Hip Osteoarthritis	3	2.8
Total	108	100

Table 5. Distribution of restriction type used in dogs necessitating FHNE

Kind of restriction	Number of Dogs	*Percentage of Dogs (%)*
No running and jumping, short leashed walks	77	81.9
No restriction	14	13
Cage rest and short leashed walks	8	8.5
Indoor restriction	4	4.3
Dog leashing and short leashed walks	3	3.2
Restriction to a small place, free to run and jump	2	2.1
Total	108	100

statistically significant correlation between these parameters (r=0.247, p=0.021).

Time of final weight-bearing of the limb

The range of TFWB of the limb undergoing FHNE was 30-365 days (mean 126, median 120). The correlation between perioperative parameters and TFWB is shown in Table 6.

Postoperative progress

Three years postoperatively, 94 dogs (87%) had a full recovery of limb's weight-bearing, 7 dogs (6.5%) showed grade 2/5 lameness, 6 dogs (5.6%) showed grade 1/5 lameness, and only one dog (0.9%) showed grade 3/5 lameness. After exercise, 46 dogs (42.6%) showed varying grades of lameness, which decreased after rest. Grade 3/5 lameness appeared for most of them.

The activity level increased in 18 dogs (16.7%), remained stable in 79 dogs (73.1%), and decreased in 11 dogs (10.2%). Movement speed increased in 19 dogs (17.6%), did not change in 76 dogs (70.4%), and decreased in 13 dogs (12%). According to 11 owners (10.2%), their dogs' willingness to play increased and one (0.9%) noticed a decrease, but most of them (88.9%) did not observe any change. Friendly behavior towards people and other animals improved in two dogs (1.8%) and remained unchanged in the rest of them (98.1%). Finally, dogs' exercise endurance increased in 20 cases (18.5%), remained unchanged in 76 cases (70.4%), and decreased in 12 cases (11.1%).

According to the answers of questionnaire, most owners (81.75%) noticed that their dog's quality of life was the same as before they became lame due to coxofemoral joint disease, 21 observed improvement (19.4%), and 6 (5.55%) noticed a deterioration. The majority of them would make the same decision again for their dog (102 respondents, 94.4%) and would also recommend it to another dog owner if needed (103 respondents, 95.4%).

Table 6. Correlation between parameters and final limb's weight-bearing

	Final weight-bearing	
Parameters	**Pearson test**	**Spearman test**
Age	r = -0.123 p = 0.235	rho = -0.007 p = 0.946
Weight	r = 0.018 p = 0.860	rho = -0.144 p = 0.164
Chronicity	r = 0.346 p = 0.001*	rho = 0.388 p < 0.001*
Physical therapy	r = -0.043 p = 0.681	rho = -0.068 p = 0.514
Restriction	r = -0.051 p = 0.620	rho = 0.023 p = 0.823
Analgesia	r = 0.247 p = 0.021*	rho = 0.134 p = 0.217

*statistically significant difference

DISCUSSION

This study reports the outcomes of dogs with hip disorders treated with FHNE, based on the retrospective study of their clinical records, while the postoperative follow-up was approached based on a questionnaire. The analysis of these data was aimed at identifying the effect of both pre-operative and post-operative factors in the animal's rate of recovery and TFWB. However, similar scientifically accepted published studies have also been based on the collection of data by questionnaires (Duff and Campbell, 1977; Bonneau and Breton, 1981; Lippincott,1987; Piek et al., 1996). Therefore, this procedure makes the results subjective and acceptable with reservations, but the importance of these studies should not be diminished.

When assessing the outcomes 3 years after surgery, gait recovery was complete in 87% of cases, while 13% had mild lameness, and one dog had intermittent weight-bearing lameness. This result may be due to the increased activity level of the dogs postoperatively and by extension to the owner's non-compliance with postoperative instructions. Generally, persistent lameness is reported to be the result of pain, weakness, limb-length difference or altered muscle-activity pattern (Lee and Fry, 1969; Harper, 2017; Liska et al., 2017; Engstig et al., 2022). The radiographs in our study showed the formation of bony prominences on the ostectomy surface several months after surgery, particularly in animals with delayed limb weight-bearing. However, the presence of these protrusions was not always related to the appearance or grade of limb lameness in our study.

According to the owners' responses, TFWB of the operated limb ranged from 30 to 365 days, which is similar to the reported range of 60 to 365 days postoperatively (Rawson et al., 2005; Off and Matis, 2010; Fattahian et al., 2012). The results of our study regarding the positive role of FHNE in gait recovery are consistent with the literature (Duff and Campbell, 1977; Berzon et al., 1980; Harasen, 2004). However, a publication from the University of Munich examined 66 dogs and 15 cats that underwent FHNE and graded the recovery of gait based on objective criteria (gait analysis corridor, range of passive movements of the joint). The recovery of gait was graded as unsatisfactory in 42% of animals at 4 years postoperatively. This result is not consistent with either the percentage of animal owners who declared they were satisfied (96%) with the evolution of FHNE, or with other studies based on questionnaires (Hofmeyr, 1966; Duff and Campbell, 1977; Gendreau and Cawley, 1977; Bonneau and Breton, 1981; Lippincott, 1984; Piek et al, 1996;). In this study, 94.4% of the owners would make the same decision due to the overall improvement in the quality of life of their dogs.

When the owners were asked about the grade of lameness after exercise, they reported no lameness in the majority of cases, while the lameness was grade 3 in the rest of the cases. In each case, lameness decreased after rest. These results are also compatible with other studies, which have associated lameness with humidity, low temperature, and intense exercise. Also, lameness after FHNE could be associated secondary to the weakness in the hip area due to loss of the ball-and-socket joint, and the need for the fibrous tissue and muscles to support weight bearing.

The correlation between age and the postoperative development of patients that underwent FHNE is a controversial point in the literature. In our study, the statistical analysis showed no correlation between them, which is compatible with some of the literature (Off and Matis, 2010; Ober et al., 2018). However, some researchers positively support this relationship, even when it is not statistically proven (Duff and Campbell, 1977; Fattahian et al., 2012; Harper, 2017; Ober et al., 2018). This association could be related to degenerative joint disease, of which the progression depends on age and the underlying cause, making it confounded with chronicity.

A positive correlation between the disease's chronicity and the limb's final weight-bearing was observed in this study, as well as in other published studies (Duff and Campbell, 1977; Harasen, 2004; Fattahian et al., 2012; Harper, 2017). Chronicity is almost synonymous with preoperative lameness and is expressed by muscle atrophy. If muscles are already atrophic, their strain will be even greater, and the recovery time will be longer (Fattahian et al., 2012; Harper, 2017).

The statistical relation between the underlying disorder that necessitated FHNE, and the outcome was proven to be significant in only the case of ANFH, which seems to delay the final recovery. A similar correlation has not been reported in the literature. However, in only some cases of small dogs, the return to function is prevented due to muscle atrophy associated with chronic ANFH or a lower pain threshold of the animal (Harasen, 2004).

Another patient-related factor is body weight. The outcome of FHNE is often considered to be related to dog's size (Peycke, 2011; Fitzpatrick et al., 2012), and there is general agreement that small animals cope better with the absence of the hip joint (Duff and Campbell, 1977; Olmstead, 1995; Ober et al., 2018). A basic theory is that more weight must be supported by pseudoarthrosis in large dogs, which could lead to pain and more pronounced displacement of the proximal resected femur craniodorsally during the limb's weight-bearing. This would cause altered limb use which could be more evident visually (Duff and Campbell, 1977; Lippincott, 1981; Harasen, 2004). Some studies report better postoperative results in dogs weighing up to 20 kg (Gendreau and Cawley, 1977; Lippincott, 1981), but this is not always confirmed by other researchers (Manley, 1993; Fattahian et al., 2012; Ober et al., 2018;), even when objective evaluations are used (Off and Matis, 2010). In our study, no statistical correlation was found between body weight and the limb's final weight-bearing. Therefore, although the change in gait is more easily detected in large dogs, it may not necessarily be related to reduced joint function or patient discomfort (Grisneaux et al., 1999; Harasen, 2004; DeCamp et al., 2016).

Regarding the postoperative instructions, the importance of the restriction of physical activity on the outcome was evaluated. In the case of FHNE, strict restriction is contraindicated, while early use of the limb should be encouraged; otherwise, the fibrous tissue will limit the range of motion of the hip joint. According to Grisneaux et al. (1999), owners are instructed to keep the duration of walks to 10 minutes for the first month postoperatively. Afterwards, a gradual increase in duration (but not in intensity) is recommended. However, this parameter was not shown to be statistically related to the time of final weight-bearing.

In the same way, physiotherapy is used to recover the hip's normal range of motion and consequently build muscle strength (Berzon et al., 1980, Penwick, 1992; Dycus et al., 2017). Physical therapy exercises should be started within 48 hours after FHNE (Colvero et al., 2020), but its effect is considered favorable even when its start is delayed (Schrader, 1996). Initially, passive flexion and extension movements of the false joint are performed, and after 2-3 weeks, active weight-bearing activities are begun (e.g., overcoming obstacles, swimming, and hydrotherapy) (Lippincott, 1981; Grisneaux et al., 1999; DeCamp et al., 2016; Harper, 2017;). However, the long-term benefit of all these exercises should not be assumed because in many patients, these manipulations may worsen the pain at the site of surgical healing (Grisneaux et al., 2003).

In our study, although dogs that underwent physical therapy had a higher TFWB than those that did not, this difference was not significant. Maybe the wide variation in the type and effectiveness of physical therapy in these patients precluded identifying any differences.

Although many studies have reported contradictory information regarding the outcome of FHNE, we consider that our study contributes to the enrichment of this literature by adding information about the association of factors that have been insufficiently studied, such as the underlying disease necessitated FHNE. However, one limitation of the present study is the lack of objective criteria for postoperative progress evaluation. Furthermore, there was large variation in breed, age, and body weight, and the majority of dogs were small or medium sized.

In addition, incomplete or biased recall of events by the owners is possible due to the length of time that passed between surgery and completion of the questionnaire. An important advantage of this work is the large size of the sample that met the inclusion criteria. However, in order to evaluate all the factors that influence the post-operative outcome of dogs that undergo FHNE, it is considered necessary to study populations of animals that are chosen based on objective criteria and compared with control groups.

CONCLUSIONS

A dog's age and body weight, postoperative activity restriction, physical therapy, and the administration of analgesics did not affect the outcome of FHNE in this study group. The disease's chronicity and, by extension, muscle atrophy negatively affect the progress after surgery. Hip luxation and ANFH are the most frequent indications of FHNE, while acetabular fractures and hip dysplasia are the rarest. To the best of our knowledge, this is the first study to show a positive correlation between the limb's final weight-bearing and ANFH.

REFERENCES

Anderson A (2011) Treatment of hip dysplasia. J Small Anim Pract 52(4): 182–189.

Berzon JL, Howard PE, Covell E, Trotter J, Dueland R (1980) A retrospective study of the efficacy of femoral head and neck excisions in 94 dogs and cats. Vet Surg 9(3): 88-92.

Bjorling DE, Chambers JN (1986) The biceps femoris flap and femoral head and neck excision in dogs. Compend Contin Educ Pract Vet 8: 359–363.

Bonneau NH, Breton L (1981) Excision arthroplasty of the femoral head. Can Pract 8(2): 13-25.

Colvero A, Schwab M, Ferrarin M, Ripplinger A, Herculano L, Wrzesinski M, Rauber J, Mazzanti A (2020) Physical therapy treatment in the functional recovery of dogs submitted to head and femoral neck ostectomy: 20 cases. Cienc Rural 50 (11): 1-8. https://doi.org/10.1590/0103-8478cr20190545

DeCamp CE, Johnston SA, Dejardin LM, Schaefer SL (2016) The hip joint. In: Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopedics and Fracture Repair. 5th ed, Elsevier, St. Louis: pp 468–517.

Denny HR, Butterworth SJ (2000) The hip. In: A Guide to Canine and Feline Orthopedic Surgery. 4th ed Blackwell, Oxford: pp 455–491.

Dueland RT, Dogan S, Vanderby R (1997) Biomechanical comparison of standard excisional hip arthroplasty and modified deep gluteal muscle transfer excisional arthroplasty. Vet Comp Orthop Traumatol 10: 95–100.

Duff R, Campbell JR (1977) Long term results of excision arthroplasty of the canine hip. Vet Rec 101: 181–184.

Duff R, Campbell JR (1978) Radiographic appearance and clinical progress after excision arthroplasty of the canine hip. J Small Anim Pract 19: 439-449.

Dycus DL, Levine D, Ratsch BE, Marcellin-Little DJ (2017) Physical rehabilitation for the management of canine hip dysplasia: 2021 update. Vet Clin North Am Small Anim Pract 52(3): 719–747.

Engstig M, Vesterinen S, Morelius M, Junnila J, Hyytiäinen HK (2022) Effect of Femoral Head and Neck Osteotomy on Canines' Functional Pelvic Position and Locomotion. Animals12: 1631.

Eyarefe OD, Oyetayo NS (2016) Prevalence and pattern of small animal orthopaedic conditions at the Veterinary Teaching Hospital, University of Ibadan. Sokoto J Vet Sci14(2): 8-15.

Fattahian H, Mohyeddin H, Hoseinzadeh A, Akbarein H, Moridpour R (2012) Excision arthroplasty of the hip joint in dogs: The role of age, weight, degenerative joint disease on the outcome. Kafkas Univ Vet Fak Derg 18: 431–436.

Fitzpatrick N, Pratola L, Yeadon R, Nikolaou C, Hamilton M, Farelli M (2012) Total hip replacement after failed femoral head and neck excision in two dogs and two cats. Vet Surg 41(1): 136-142.

Gendreau C, Cawley AJ (1977) Excision of the femoral head and neck: the long-term results of 35 operations. J Am Anim Hosp Assoc 13: 605-608.

Girdlestone GR (1928) Arthrodesis and other operations for tuberculosis of the hip. In: Milford HW (ed) The Robert Jones Birthday Volume. Oxford University Press, London: pp 347–374.

Girdlestone GR (1943) Acute pyogenic arthritis of the hip: An operation giving free access and effective drainage. Lancet 241: 419–421.

Grisneaux E, Pibarot P, Dupuis J, Blais D (1999) Comparison of ketoprofen and carprofen administered prior to orthopedic surgery for control of postoperative pain in dogs. J Am Vet Med Assoc 215(8): 1105–1110.

Grisneaux E, Dupuis J, Bonneau NH, Charette B, Blais D (2003) Effects of postoperative administration of ketoprofen or carprofen on short- and long- term results of femoral head and neck excision in dogs. J Am Vet Med Assoc 223(7): 1006-1012. https://doi.org/ 10.2460/javma.2003.223.1006

Harasen G (2004) The femoral head and neck ostectomy. Can Vet J 45: 163-164.

Harper TAM (2017) Femoral head and neck excision. Vet Clin Small Anim 47: 885–897.

Hofmeyr CFB (1966) Excision arthroplasty for canine hip lesions. Mod Vet Pract 47: 56-58.

Krystalli A, Sideri A, Kazakos MG, Anatolitou A, Prassinos NN (2023) Contribution to the study of perioperative factors affecting the restoration of dog's mobility after femoral head and neck excision. A clinical study in 30 dogs. Animals 13(14): 2295. https://doi.org/10.3390/ani13142295.

Lee R, Fry PD (1969) Some observations on the occurrence of Legg-Calvé- Perthes' disease (Coxaplana) in the dog, and an evaluation of excision arthroplasty as a method of treatment. J Small Anim Pract 10: 309-317.

Lewis DD (1992) Femoral head and neck excision and the controversy concerning adjunctive soft tissue interposition. Compend Contin Educ Pract Vet 14: 1463–1470.

Lippincott CL (1981) Improvement of excision arthroplasty of the canine femoral head and neck utilizing a biceps femoris muscle sling. J Am Anim Hosp Assoc 17: 668-672.

Lippincott CL (1984) Excision arthroplasty of the femoral head and neck utilizing a biceps femoris muscle sling. Part two: The caudal pass. J Am Anim Hosp Assoc 20: 377-384.

Lippincott CL (1987) A summary of 300 surgical cases performed over an 8-year period: excision arthroplasty of the femoral head and neck with a caudal pass of the biceps femoris muscle sling. Vet Surg 16(1): 96.

Liska WD, Doyle ND, Schwartz Z (2010) Successful revision of a femoral head ostectomy (complicated by postoperative sciatic neurapraxia) to a total hip replacement in a cat. Vet Comp Orthop Traumatol 23(2): 119-123.

Manley PA (1993) The hip joint. In: Slatter D (ed) Textbook of Small Animal Surgery. 2nd ed, WB Saunders, Philadelphia: pp 1798–1799.

Ober C, Pestean C, Bel L, Taulescu M, Milgram J, Todor A, Ungur R, Lesu M, Oana L (2018) Use of clinical and computed tomography findings to assess long-term unsatisfactory outcome after femoral head and neck ostectomy in four large breed dogs. Acta Vet Scand 60: 28. https://doi.org/10.1186/s13028-018- 0382-8

O'Donnell MD, Warnock JJ, Bobe G, Scholz RP, Wiest JE, Nemanic S (2015) Use of computed tomography to compare two femoral head and neck excision ostectomy techniques as performed by two novice veterinarians. Vet Comp Orthop Traumatol 28(05): 295–300.

Off W, Matis U (2010) Excision arthroplasty of the hip joint in dogs and cats. Clinical, radiographic, and gait analysis findings from the Department of Surgery, Veterinary Faculty of the Ludwig-Maximilians-University of Munich, Germany. Vet Comp Orthop Traumatol 23(5): 297–305.

Olmstead ML (1995) The canine cemented modular total hip prosthesis. J Am Anim Hosp Assoc 31(2): 109–124. https://doi.org/10.5326/15473317-31-2-109

Penwick RC (1992) The variables that influence the success of femoral head and neck excision in dogs. Vet Med 4: 325–333.

Peycke LE (2011) Femoral Head & Neck Ostectomy. Procedures Pro-Orthopedics Peer Reviewed 55-59.

Piek CJ, Hazewinkel HA, Wolvekamp WT, Nap RC, Mey BP (1996) Long-term follow-up of avascular necrosis of the femoral head in the dog. J Small Anim Pract 37(1): 12–18.

Piermattei DL, Flo GL, DeCamp CE (2006) The hip joint. In: Handbook of Small Animal Orthopaedics and Fracture Repair. 4th ed, Elsevier, St. Louis: pp 461–511.

Prostredny JM (2014) Excision arthroplasty of the femoral head and neck. In: Bojrab MJ (ed) Current techniques in small animal surgery. 5th ed, Teton NewMedia, Jackson: pp 1048-1052.

Rawson EA, Aronsohn MG, Burk RL (2005) Simultaneous bilateral femoral head and neck ostectomy for the treatment of canine hip dysplasia. J Am Anim Hosp Assoc 41(3): 166–70.

Roush JK (2012) Surgical therapy of canine hip dysplasia. In: Tobias KM, Johnston SA (eds) Veterinary surgery small animal. Elsevier Saunders, St Louis (MO): pp 849–864.

Schrader SC (1996) Clinical experience with excisional arthroplasty of the hip (abstract). Proc Amer Coll Vet Surg Annu Meet 40.

Schulz KS, Dejardin LM (2003) Surgical treatment of canine hip dysplasia. In: Slatter D (ed) Textbook of Small Animal Surgery. 3rd ed, Elsevier Science, Philadelphia: pp 2029-2059

Stanton ME, Weigel JP, Henry RE (1988) Ischiatic nerve paralysis associated with the biceps femoris muscle sling: case report and anatomic study. J Am Anim Hosp Assoc 24(4):429-432.

Funding information
This study is part of a doctoral thesis. The implementation of the doctoral thesis was cofinanced by Greece and the European Union (European Social Fund—ESF) through the Operational Programme Human Resources Development, Education and Lifelong Learning in the context of the Act "Enhancing Human Resources Research Potential by undertaking a Doctoral Research" Sub-action 2: IKY Scholarship Programme for PhD candidates in the Greek Universities (grant number 2022-050-0502-52327).

Author Contributions
All authors contributed to the study conception and design. A.A. Krystalli: Material preparation, formal analysis, investigation, writing-original draft. A.I. Sideri: writing-review & editing. G. Kazakos: Data collection, writing-review & editing. S.K. Papaefthymiou: Data collection, writing-review & editing. A.A Anatolitou: writing-review & editing. I Savvas: visualization, writing-review & editing. N.N. Prassinos: Project administration, writing-review & editing. *All authors read and approved the final manuscript.*

Ethics approval
It is not necessary for this work because it is a retrospective study.

Consent to participate
Informed consent was obtained from all individual participants included in the study.