PhD THESIS

# Canine hip dysplasia: modern methods and techniques for diagnosis

(SUMMARY OF THE PhD THESIS)

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# INTRODUCTION

The word 'dysplasia' originates from the Greek language and is composed of the prefix 'dis' meaning 'abnormal/difficult' and the suffix 'plassein' meaning 'to form', which can be translated as: 'an abnormal development' (GUILLIARD, 2014).

Canine hip dysplasia was first described in 1935 by Dr Gerry B. Schnelle, being characterized by joint instability, subluxation or dislocation of the femoral head, which causes a deformity of the joint with the early production of coxarthrosis (MORTELLARO ET Al., 2008; KING, 2017). Hip dysplasia in dogs can occur due to genetic predisposition (25-85%) (SHIJU ET AL., 2010) and different environmental factors such as inadequate nutrition, too rapid body development or due to hormonal imbalances (SCHACHNER AND LOPEZ, 2015).

From the first mention of this condition to the present day the entire veterinary community has been engaged in the fight of controlling and reduceing the occurrence of hip dysplasia in dogs because it has a major impact on the wellbeing of the patient, and indirectly, of the owners as well (KING, 2017; MIKKOLA, 2020).

The motivation for this study was influenced by two significant aspects: the lack of comprehensive data on the incidence of hip dysplasia in romanian dogs, which makes it challenging to develop effective prevention and management strategies for the condition, and the existence of highly diverse diagnostic and treatment methods that can create confusion and uncertainty among veterinarians and pet owners. It is essential to identify and implement the most effective and precise diagnostic methods to ensure appropriate and prompt treatment.

Therefore, the primary aim of this research is to bring clarity and consistency to the diagnosis of canine hip dysplasia. Identifying and applying the latest and most effective diagnostic methods will allow for early and accurate diagnosis of the condition, thus facilitating the establishment of appropriate treatment and improving the quality of life for affected patients.

Based on this goal, we have set the following objectives:

1. Evaluation of canine hip dysplasia grades, in accordance with FCI standards, of patients within the Radiology and Veterinary Medical Imaging Service of FMV-Cluj.
2. Hip joint laxity radiological evaluation and changes induced by hip dysplasia using Brass parameters
3. Description of the radiological and imaging characteristics of the 'cloud sign', which occurs as a result of metallosis, a complication of total hip replacement.

# STRUCTURE OF THE DOCTORAL THESIS

The thesis entitled "Canine hip dysplasia: modern methods and techniques for diagnosis" consists of 103 pages that have been written in accordance with current editing standards. The doctoral thesis is structured into two parts consisting of 7 chapters and contains 33 figures, 7 tables, and 116 bibliographic references.

**The first part** is entitled "Current state of knowledge" and comprises 4 chapters totaling 22 pages. This part presents details regarding the anatomy and physiology of the hip joint in dogs **(Chapter 1)**, the etiology and main triggering factors of hip dysplasia **(Chapter 2)**, the main diagnostic **(Chapter 3)** and treatment methods **(Chapter 4)**.

**The second part** of the doctoral thesis is dedicated to original research. This is structured into 7 chapters and comprises 57 pages.

**Chapter 5** presents the aim and objectives of the current research. We aim to contribute to the understanding and approach of the hip dysplasia in dogs, as well as to provide clarity and coherence regarding the diagnosis and the treatment of the disease.

**Chapter 6** presents **Study I**, entitled: Canine hip dysplasia incidence in radiology and diagnostic imaging department of the Faculty of Veterinary Medicine – Cluj. This is the first study in Romania to include complete data on the breed, age, sex, and weight of the included patients. The interpretation of the x-rays and the assignment of the corresponding dysplasia grade were performed in accordance with the requirements of the International Cynological Federation. A relatively low incidence of hip dysplasia was observed in our patients, being 43 %.

**Chapter 7** includes **Study II**, entitled: Canine hip dysplasia diagnosis through measuring hip laxity and through the Brass method. This research combines two studies that ultimately have the same goal, namely the most accurate method for diagnosis of canine hip dysplasia. One of the major risk factors for the occurrence of hip dysplasia in dogs, as Brass also stated, is passive hip laxity. This occurs early in the patient's life, causing subluxation of the femoral head, coxo-femural incongruency, and acetabular abnormalities. The pathophysiological mechanism initially involves abnormal development of endochondral ossification, which triggers an inflammatory response, resulting in the appearance of degenerative acetabular changes clinically manifested by lameness, pain, and joint immobility (SANTANA, 2022; BRASS, 1989). Assessing of the hip joint laxity was performed using the AIS PennHIP method, which has the advantage of being eligible from the age of 4 months. Hip joint laxity was determined in 11 patients, and the Brass criteria were applied to 210 patients, totaling 420 hip joints evaluated separately according to 16 radiological criterias.

**Chapter 8** is dedicated to **Study III**: Total Hip Replacement and one of its complications: metallosis. It is known that total hip arthroplasty is a surgery that

relieves pain and presents the best results in dogs with severe dysplasia, as well as in those with osteoarthritis consequent to it. In this study, the 'cloud sign' was described for the first time in veterinary medicine, which appears in the case of prosthetic implant failure and metallosis.

# RESULTS OF THE ORIGINAL RESEARCH

**Chapter 6.** During the period between October 2019 and June 2021, approximately 173 ventro-dorsal x-rays exposures of the pelvis were performed on various breeds of dogs at the Service of Radiology and Veterinary Medical Imaging of the Faculty of Veterinary Medicine in Cluj-Napoca. For this study, 88 patients were excluded due to: pelvic or femoral fractures (fig. 1B), incorrect positioning (fig. 1C), immature skeleton, femoral head necrosis, and orthopedic surgeries at this level (fig. 1A).


**Fig. 1.** Rejected radiographs for examination: A- Surgical intervention; B-Left coxo-femural luxation and pubic fractures; C-improper positioning

A total of 85 dogs of various breeds were included in the study, thus evaluating 170 hip joints. The most frequent breeds in the study were: Cane Corso, Labrador Retriever, German Pointer, Lagotto Romagnolo, etc. The study included 15% mixed-breeds dogs, while the remaining 85% were purebred dogs.

Out of the total of 85 patients, more than 45% (38 patients) had normal joints without any changes, corresponding to grade A in the FCI system; 12% had grade B (10 patients), and those with evident signs of hip dysplasia accounted for almost 43% (22 patients with grade C, 6 patients with grade D, and 9 patients with grade E).

Of the 37 patients with a degree of hip dysplasia (C, D, or E), 20 of them had bilateral dysplasia, while the remaining 17 cases were diagnosed with unilateral

dysplasia. Of the 17 cases with unilateral dysplasia, in 12 cases, the right limb was classified as either grade A or B, and in 5 cases, the left limb was classified as such.

In according to the recent research, there is an upward trend in the incidence of this condition over time. This evolution can be partialy explained by technological advancements and improvements in diagnostic equipment, which have facilitated a more accurate identification of the condition. Additionally, it is important to consider the continuous specialization of veterinarians, enabling them to be more effective in diagnosing and managing this complex condition (KING, 2017).

**Chapter 7.** The hip laxity was determined using the AIS PennHIP method, in which three ventro-dorsal x-rays are taken, and in the third one, called the 'distraction view' (fig. 2), hip joint laxity is measured using the formula: DI = d/r (where DI = hip joint laxity index, d = distance between the two centers of femoral head and acetabular cavity, and r = radius of the femoral head). The hip with the highest joint laxity will be considered for reporting.

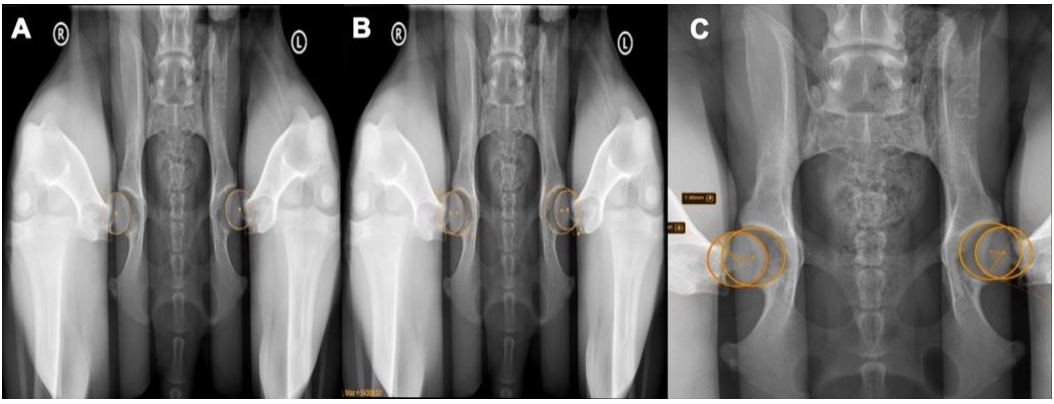


**Fig.** 2 Distraction view for the measurement of the hip joint laxity index using the PennHIP method. A - Circumscribing the femoral heads, B - Encircling the acetabular cavity, C - The horizontal line that connects the centres of the two circles previously determined (d), divided by the radius of the femoral head (r) and calculating the joint laxity index (DI=d/r).

Out of a total of 11 patients, none had DI values below the reference value of 0.3.

According to AIS, patients with a DI below the breed average can be used in breeding programs. Thus, out of 11 patients, 8 had a DI below the breed average.

The Brass method involves a descriptive evaluation of the acetabular cavity (acetabular depth, dorsal acetabular rim, craniolateral acetabular rim, and acetabular osteophytes), the femoral head, its position in the acetabular cavity, the femoral neck, the joint space, and the Norberg angle (PINNA, 2022).

Since the Brass method is a qualitative method that does not provide numerical values for changes in the hip, PINNA, 2022, modified this method by assigning values between 0-2 to the changes that occur. The study population included 210 dogs of

different breeds. There were 116 males (55.2%) and 94 females (44.8%). The average age was 31 months, and the average weight was 33 kilograms. The breeds with the highest proportions were: Dogo Argentino 23 (11%), Labrador Retriever 21 (10%), Cane Corso 20 (9.5%), German Shepherd 15 (7.1%), German Pointer 13 (6.2%), mixed breeds 18 (8.6%), while the remaining breeds had a proportion of less than 5% in this study.

**Chapter 8.** In this study, we described the radiological features occurring in metallosis, a well-known complication of total hip replacement in human medicine, but poorly described in veterinary medicine. A two-year-old female Akita Inu was presented for a computed tomography (CT) evaluation due to discomfort during the extension of the left hip, joint crepitus upon manipulation of the same hip, and muscle atrophy of the left hind limb. The patient had a history of bilateral hip dysplasia, for which a double pelvic osteotomy (DPO) was performed on the right hip and a total hip replacement (THR) on the left limb. Additionally, the patient had a complete rupture of the cruciate ligaments in the left limb, for which a tibial plateau leveling osteotomy (TPLO) was performed.

Radiographic images obtained prior to the CT examination revealed medio-dorsal displacement of the prosthetic femoral head in the left limb as well as periosteal reaction with irregular margins and osteolysis at the level of the greater trochanter of the femur, all indicating a failure of the femoral implant. In addition to the previously described findings, a mixed soft tissue-mineral opacity was observed around the proximal femur and the prosthetic stem, indicating the so-called 'cloud sign' (Fig. 3), which is compatible with metallosis in human medicine.

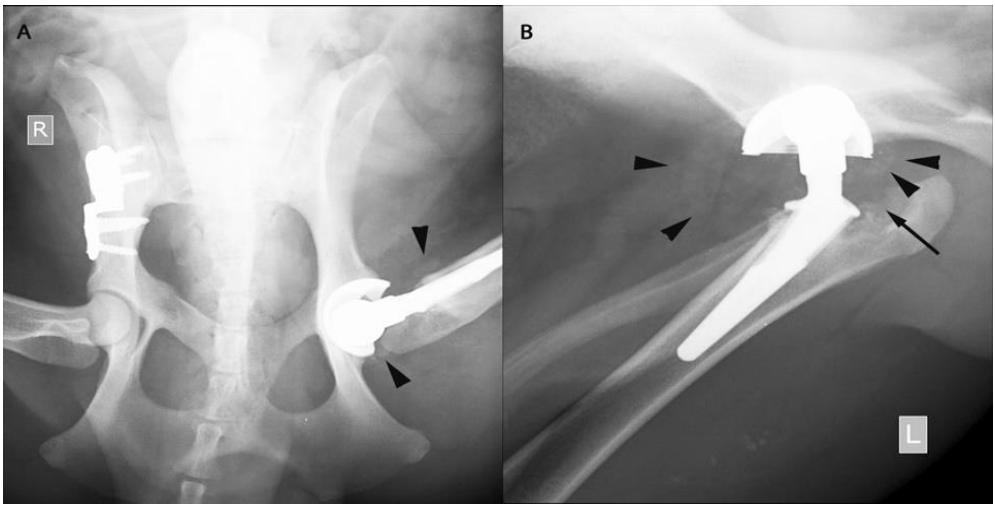


**Fig.** 3 Ventro-dorsal exposure of the pelvis and medio-lateral view of the left hind limb. A - B Mixed soft-tissue to mineral opacity in the proximal left femur consistent with the 'cloud sign' (arrowhead), and osteolysis in the greater trochanter (black arrow).

The abdominal-pelvic CT scan (native and contrast) revealed significant dorsomedial displacement of the prosthetic femoral head, the presence of geographic osteolysis areas at the level of the greater trochanter of the femur, and multiple amorphous areas of mixed mineral-metal attenuation, consistent with the 'cloud sign,' diffusely distributed in the peri-prosthetic soft tissues (Fig. 4).

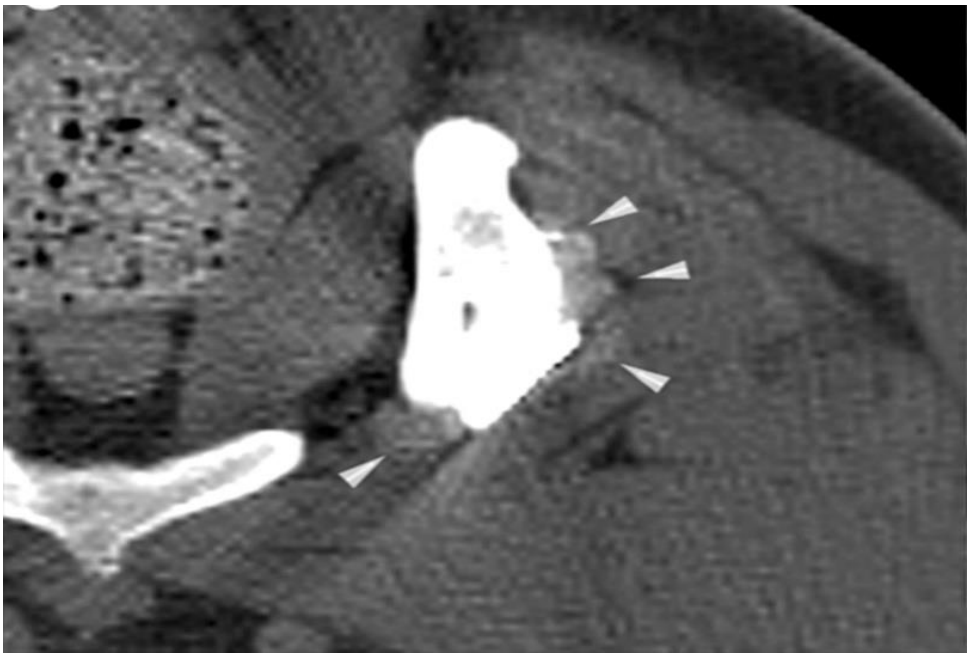

**Fig.** 4 Axial view in soft tissue windowing showing the 'cloud sign' surrounding the prosthetic head (white arrowheads)

This study is the first one in veterinary medicine which describe the radiological and CT characteristics of the 'cloud sign' in a patient with prosthetic hip implant failure and metallosis. Therefore, radiological and CT examinations can be used in cases of suspected orthopedic implant failure and subsequent metallosis.

# GENERAL CONCLUSIONS

In the **Chapter 10** of the thesis the general conclusions formulated based on the results obtained are presents as follows:

The number of patients with hip dysplasia has been on an upward trend in recent decades, which may be partially real due to technological advancements and the continuous specialization of veterinary radiologists, leading to increased diagnostic accuracy.

Radiological procedures necessary for diagnosing canine hip dysplasia must be performed under general anesthesia, as any change in the pelvic axis alters the measurements taken.

Diagnostic methods for hip dysplasia in dogs, proposed by the major organizations involved in the screening tests for the condition, require patients to reach musculoskeletal maturity at the time of radiological examination. Determining joint laxity is essential to predict the likelihood of developing the condition in adulthood.

For an accurate diagnosis, it is important to evaluate the hip joints individually and analyze each anatomical structure involved. A detailed approach to radiological images allows for the identification of all pathological changes, including subtle ones, which can be relevant for the diagnosis and management of canine hip dysplasia

For evaluating bone integrity and the implanted material, radiological examination is the first step, while CT examination provides additional information in case of radiologically detected changes.

The CT and radiological sign of metallosis as a complication of total hip arthroplasty in dogs is the 'cloud sign.' This consists of areas with soft tissue/mineral attenuation or opacity around the implant, suggesting the accumulation of metal debris in the adjacent tissues.

The radiologist must report any changes in the hip joint that has undergone total replacement. Regular monitoring of patients after total hip replacement is crucial for the early detection of complications and the implementation of appropriate treatment before these complications become severe or affect the clinical outcomes of the patient.

# RECOMMENDATIONS

Following the previous conclusions, it is recommended to evaluate the hip joint using the Brass method, as it considers no less than 16 distinct radiological criterias.

A CT examination in case of total hip implant is necessary when clinical signs or radiological changes appear.

Considering that most organizations for screening hip dysplasia recommend reaching musculoskeletal maturity before performing x-rays, determining joint laxity should be included in the standard protocol, as it can indicate the patient's susceptibility to developing osteoarthritis consequent to hip dysplasia, allowing the orthopedic or attending veterinarian to determine the most optimal treatment.

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