From the Health and Genetics Committee

Hip and Elbow Dysplasia: Successes and Challenges

Some of us began sharing our lives with Golden Retrievers many years ago. Looking back 40 to 50 years ago, hip dysplasia was common and often severe in Golden Retrievers. The problem was not limited to North America nor to Golden Retrievers. The problem involved predominantly dogs weighing more than 50 pounds. Many of us remember the struggles back then of some amazing dogs whose lives were sometimes tragically altered or even cut short by hip dysplasia and other forms of degenerative joint disease. With time, advances in veterinary medicine enabled the identification of some forms of degenerative joint disease using standard radiographs.

By the start of this century, radiographic screening of hips and elbows in breeding dogs became an expected part of health testing for Golden Retrievers. However, procedures and ages for screening hips and elbows differ in different countries, and it can be important to understand these differences when we seek outcross bloodlines. The good news is that routine hip and elbow dysplasia screening has greatly reduced the frequency of these disabling joint disorders when breeders carefully consider the hip and elbow evaluations of potential breeding dogs. Ideally, this involves considerations of screening results from the potential breeding dogs and their close relatives, including siblings, sire, dam and offspring.

The purpose of this article is to share the screening procedures developed worldwide, the factors found to affect the screening results, the things owners and breeders can do to reduce risk, and the potential future role of modern techniques including computed tomography (CT) and genetic testing.

What is hip dysplasia?

Hip dysplasia is a condition of the hip joint characterized by a loose hip joint, degeneration of the cartilage that protects the joint, changes in the shape of the bones of the hip joint, and by arthritis (joint inflammation) (21).

In the normal hip joint, the femur (long bone of the upper hind leg) fits tightly into the acetabulum (socket of the hip joint) as shown in Figure 1.

What is elbow dysplasia?

The elbow joint is the hinge joint on the front leg that is responsible for movement between the lower humerus and the upper part of the ulna and radius (Figure 2). Elbow dysplasia is a developmental disease characterized by poor alignment of the parts of the joint (joint incongruity), fragmentation of the medial coronoid process of the ulna, failure of the anconeal process of the ulna to fuse with the rest of the ulna (ununited anconeal process), and/or a developmental condition of elbow joint cartilage (osteochondrosis) (2).

Hip rating schemes differ in different countries

Radiographs (x-rays) are used to evaluate the presence or

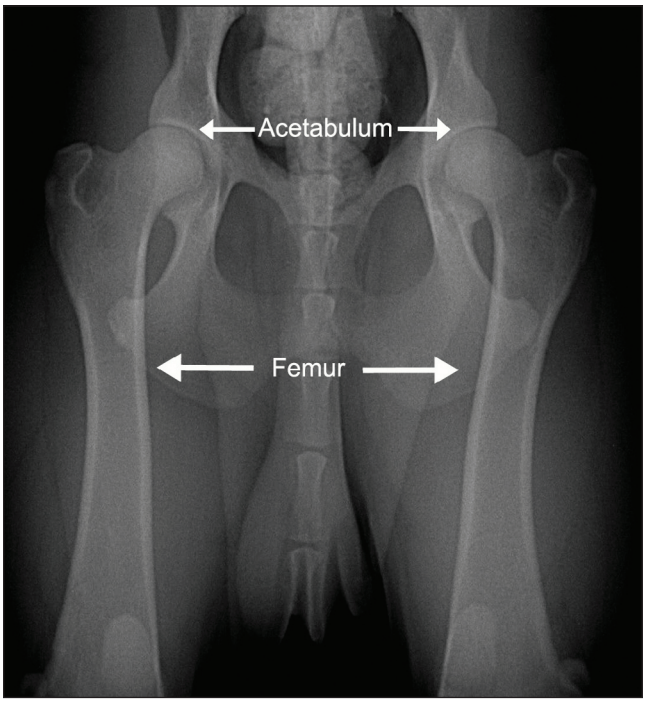

Figure 1. X-ray of normal hips from a Golden Retriever who received an excellent rating from OFA. The hip socket (acetabulum) is deep and the head of the femur fits tightly and smoothly into that socket. In contrast, in hip dysplasia, the joint is loose and has irregularities, leading to arthritis..

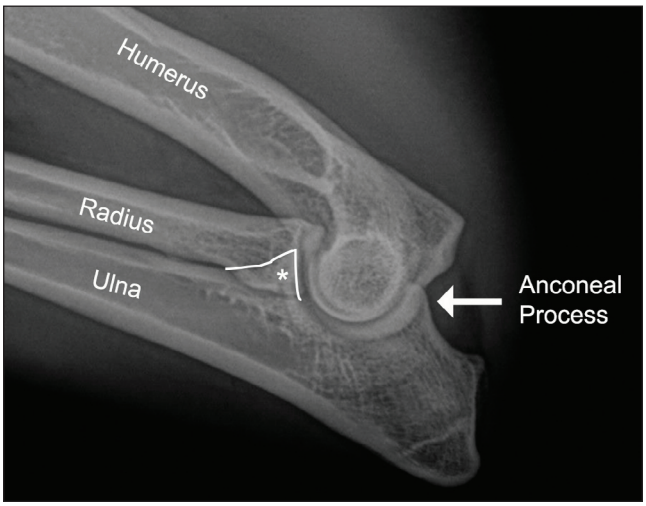

Figure 2. X-ray of the elbow of a Golden Retriever with a normal elbow joint. The elbow joint is a hinge joint between the humerus and the radius and ulna. The anconeal process (arrow) and the coronoid process (and outlined in white) are the sites in the elbow joint that are most frequently affected in elbow dysplasia. Note the very smooth margins of the anconeal process in this normal elbow joint.*

absence of hip dysplasia. The hip extended view of hips is the most common view used worldwide. The radiographs of the hips are taken with the dog lying on their back (ventral-dorsal view). Accurate positioning is required for the most accurate evaluation by the radiologists. An excellent video describing the recommended positioning for hip radiographs and the potential effect of positioning on the final evaluation is available online from the Orthopedic Foundation for Animals (OFA) (19).

As with any medical diagnosis, the accuracy of the diagnosis is dependent upon the skills of the diagnostician and specialized expertise is important. This is true for the interpretation of radiographs used to diagnose hip and elbow dysplasia. For that reason, breed clubs and in some cases the dog registries recommend or require that evaluation of hip and elbow radiographs of breeding dogs be done through organizations specializing in the evaluations.

The rating terms and some of the features used for scoring radiographs vary somewhat in different countries (Tables 1 and 2). The Federation Cynologique Internationale (FCI) screening procedure has been used for more than 40 years and is used in most of Europe, South America, Asia, South Africa and in Russia (31). In most breeds, the minimum age for evaluation is 1 year of age, although in some countries, 2 years of age is the minimum, particularly for large and giant breeds (18; 31). The Kennel Club uses a numerical scoring system (BVA) in the United Kingdom (UK) and a similar system is used in Australia and New Zealand. OFA developed a useful table that is helpful in interpreting the hip scores from different countries and the OFA data were used to create Table 1.

OFA	FCI (Europe, Asia, South America, Russia)	BVA (UK/Australia)
Excellent	A-1	0-4 (no >3/hip)
Good	A-2	5-10 (no >6/hip)
Fair	B-1	11-18
Borderline	B-2	19-25
Mild	C	26-35
Moderate	D	36-50
Severe	E	51-106

Table 1[1]: Hip dysplasia is a problem worldwide. Different terminology in different countries is used to describe the spectrum of normally conformed hips. In the table below, we have listed the comparable terms used to rate the hip conformation from best to worst by the major organizations that evaluate dogs for hip dysplasia.

1 Data from the OFA downloaded 2/4/2023. The original table at the OFA site also mentions Germany's SV rating system that is predominantly used for rating German Shepherds in Europe.

Table 2. Minimum age in months and expertise of the evaluator for final evaluation of hips and elbows in different systems.

	OFA	FCI (Europe, Asia, South America, Russia)	BVA (UK/Australia)
Minimum Age (months)	24[1]	12[2]	12
Evaluator(s) Credentials	3 certified veterinary radiologists[3]	Expert[4]	Radiology or surgical specialist(s)[5]

1. OFA certification at 24 months of age but OFA will do a preliminary evaluation for hip dysplasia as early as 4 months of age
2. The minimum age is 12 months for evaluation in most countries but can be up to 24 months for some breed clubs and countries
3. Evaluation for certification at ≥ 24 months of age by OFA is done by a panel of 3 randomly-selected board-certified veterinary radiologists from a pool of 20 or more consulting radiologists
4. FCI system is used in many countries and credentials for evaluators vary but most commonly a single evaluator is used by a breed club or country (4).
5. In the UK consensus of 2 radiology or surgical specialists (31). In Australia and New Zealand, the system is changing but it appears that the evaluator who is a member of the radiology chapter of the Australian and New Zealand College of Veterinary Scientists (1).

For hip dysplasia, the looseness of the hip joint is central to the development of many of the changes present in affected dogs, including changes in the shape of the head of femur and the socket (acetabulum). For this reason, procedures to quantify the looseness (laxity) of the hip joint are sometimes used in the diagnosis of hip dysplasia (24). Functional laxity (laxity as the dog moves) is difficult to measure. However, laxity can be evaluated on the standard OFA hip extended view and additional clinical and radiographic procedures can be used to evaluate hip laxity, particularly in young dogs and/or dogs showing symptoms of hip dysplasia (32). Among these procedures, the PennHIP procedure includes a measure of joint laxity called the distraction index (DI). However, laxity as evaluated on the standard OFA hip-extended view is not directly comparable to the DI measured in the PennHIP process. For at least some breeding colonies, the addition of DI to standard hip radiographs has produced more rapid reductions in hip dysplasia than produced by standard hip radiographs alone (7). Importantly, the relationship between DI and the development of hip arthritis varies depending upon breed. For example, if comparing German Shepherds and Golden Retrievers with the same numerical DI, the Golden Retrievers are less likely to develop

arthritis than the German Shepherds. (25). Selecting breeding dogs, with tighter hips than the median (50th percentile) for the breed has been suggested as a practical guide (25) when DI is used as a part of hip dysplasia screening.
The GRCA Code of Ethics guidelines for breeding dogs specify a report from the Orthopedic Foundation for Animals (OFA) at 24 months of age or older for elbows and for hips, a report at 24 months of age from the OFA and/or PennHIP. The results need to be recorded in an approved online database (6).

Parent selection reduces risk for hip and elbow dysplasia in the offspring

The risk for hip and elbow dysplasia is affected by genes and the environment. Heritability estimates describe the influence of genes on a condition on a scale of 0 (no effect) to 1 (entirely caused by genes). For Golden Retrievers, a 2017 study estimates the heritability of hip dysplasia scores as 0.65 and the heritability of elbow dysplasia scores as 0.29 (17). In Switzerland, where breeding of obviously dysplastic dogs has been banned for more than 50 years, prevalence of hip dysplasia was 51% between 1991 and 1995; between 1995 and 1999 the prevalence of hip dysplasia in Golden Retrievers was 25.3%, and between 2010 and 2016, the hip dysplasia rate had been reduced to 9.4% (18).

In the OFA database of all breeds, breeding a dog with normal elbows to a dog with normal elbows resulted in elbow dysplasia in ~10% of pups while the risk to the pups was approximately twice that when a dog with normal elbows was bred to a dog with grade 1 elbow dysplasia, while the risk for elbow dysplasia in the pups was ~41% when both parents had grade 1 elbow dysplasia (11).

In the US, where evaluation of radiographs is not required for breeding, where only a small portion of all Goldens get screened, and where radiographs from obviously dysplastic dogs may not be submitted, breed improvement in hip dysplasia is not as clear as in closed colonies. However, among Goldens with normal hips (where the radiographs are likely to be submitted for evaluations) a general trend appears to be present for increases in percent of good to excellent and a decrease in percent rated as fair and especially in those rated severely dysplastic (Table 3).

Table 3: Hip dysplasia percentages in Golden Retrievers evaluated by OFA over the years[1]

	<=1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020	≥2021[2]
HIPS - NORMAL	73.6	76.8	77.2	80.4	83.0	82.9	81.4	79.3
HIPS - EXCELLENT	2.3	3.9	5.0	5.5	8.6	8.5	10.3	8.6
HIPS – GOOD	45.6	48.0	48.6	51.1	54.4	57.7	55.6	69.0
HIPS - FAIR	25.7	24.9	23.6	23.8	20.0	16.7	15.5	1.7
HIPS - ALL DYSPLASTIC	24.0	19.7	18.7	17.7	15.4	15.8	16.9	17.2
HIPS - MILD	13.7	12.1	12.1	12.9	12.1	12.0	13.2	12.1
HIPS - MODERATE	9.1	6.8	5.9	4.4	3.0	3.5	3.4	5.2
HIPS – SEVERE	1.3	.9	.7	.4	.3	.3	.3	.0

[1]Data are from the OFA and were downloaded 2/4/2023
[2]It is notable that the percentage of fair ratings in Golden Retrievers dropped dramatically beginning in 2021 and why that happened is unclear [2] However the pandemic caused major staffing shortages for the veterinary profession in the US (33). Data in 2021 and after may reflect changes associated with the pandemic regarding dogs whose radiographs were submitted, the veterinarians submitting radiographs to the OFA, and the radiologists evaluating the films.

In the UK, where submission of hip and elbow radiographs for screening is voluntary just as it is in the US, data is available on the percentage of breeding dogs that get screened. From 2016 to 2018, 69.58% of Golden Retriever sires were screened for hip dysplasia but only 48.3% were screened of elbow dysplasia. For Golden Retriever dams, 73.20% were screened for hip dysplasia but only 45.73% of dams were screened for elbow dysplasia using the radiographic screening procedure in the UK, the BVA (8). Thus, slow improvement in hip and elbow dysplasia data from voluntary registries is affected by submission of films predominantly from normal dogs as well as by the continued use of some unscreened dogs for breeding.

An important tool that can be used to improve the odds of sound hips and elbows is the consideration of screening results from the potential breeding dogs themselves and their close relatives, including siblings, their sire, their dam and their offspring. The hip status of siblings, sires, dams and offspring can be viewed on the OFA vertical pedigree pages. These pedigree considerations are sometimes formalized through the calculation of estimated breeding values (EBVs) of breeding dogs from the pedigree information on hip and elbow dysplasia for their relatives (13; 14; 34).

Thus, the importance of genetics in hip and elbow dysplasia is clearly demonstrated in data from populations where hips and elbows are consistently screened and only clear offspring bred. While data from voluntary registries is not as clear, it seems likely that the risk of hip and elbow dysplasia in Goldens produced by breeders following the GRCA Code of Ethics for generations should be similar to those produced in countries that require acceptable hip and elbow rating for breeding. Because genes play an important role, breeders can help risk for hip and elbow dysplasia by selecting breeding dogs from dogs who have normal hip and elbow joints and also have close relatives demonstrated free of hip and elbow dysplasia.

Staying lean reduces the risk for hip dysplasia and arthritis

Both breeders and owners can help puppies develop normally by providing an environment that keeps them lean and minimizes risk for injury. Many puppies eat more food than they really need for optimal development and this can increase the risk for hip and elbow dysplasia, at least in the dogs prone to dysplasia. This was clearly demonstrated in a study of 48 Labrador Retrievers from 7 litters. Starting at 8 weeks of age, half of the pups (24) had unlimited access to food, while the other half (24) of the pups received 25% less food. At 2 years of age using the Orthopedic Foundation for Animals (OFA) method, 16 of the pups with unlimited food access had hip dysplasia while 7 of the pups with limited food access developed hip dysplasia (10). As the study continued, the majority of these dogs (67%) developed arthritis in hips by 14 years of age but the dogs with limited food intake develop arthritis later (median age of 12 years) than the age for arthritis onset in dogs with higher food intake (median age of 6 years) (26). Even more important to many of us is that the dogs with limited food intake had longer lifespans and later onset of chronic age-associated diseases (9).

Early spay/neuter increases the risk for hip dysplasia in Goldens

Hormones in intact dogs affect the closure of growth plates and early removal of the gonads before sexual maturity alters that process. Early spay/neuter has been associated with an increased incidence of orthopedic disease including hip dysplasia and cruciate ligament tears in Golden Retrievers, and that association may be due to removing sex hormone before the growth plates close (3; 23).

Hip conformation tends to get worse with age

Multiple studies indicate that hip and elbow dysplasia frequency increases with age (11; 15). However, the minimum age for final evaluation varies between countries (Table 2). This means that dogs with late-onset hip or elbow dysplasia may be missed in screening examinations in those countries. However, consideration of hip and elbow status of close relatives can provide useful information regarding the genetic status of potential breeding dogs and is sometimes more easily available in other countries than in the US. For example, in the UK a dog's EBV scores for hip and elbow dysplasia are recalculated four times a year and provide an estimate of the likelihood for producing hip and elbow dysplasia (27). The EBVs for any dog registered with the UK dog registry, The Kennel Club, are in a searchable database (28). In all countries the age of the dog when screened is an important consideration, with examinations at older ages being more sensitive in detecting disease. However, when considering imported semen or puppies from countries where screening examinations at less than two years of age are the standard, information about hip and elbow status of related dogs is often available and can reduce concerns related to the earlier screening.

Type of restraint can affect hip dysplasia diagnosis and ratings

In a 2007 study of Swedish dogs, the sedation method affected the diagnosis of hip dysplasia but not elbow dysplasia. Sedation with acepromazine alone resulted in roughly half the hip dysplasia diagnoses made in dogs sedated with xylazine, medetomidine or a combination or medetomidine and butorphanol (15). Acepromazine is no longer permitted as a means of sedation for evaluation of hip dysplasia in Sweden. In the US, Either physical or chemical restraint (sedation or anesthesia) can be used for hip dysplasia evaluation by OFA while anesthesia is required for the PennHIP evaluation.

New technology

New digital technology affects how radiographs are taken and submitted and the ability of owners to have copies of the radiographs from their dogs. This new technology allows the radiographs to be produced rapidly and generally with less exposure of veterinary personnel to radiation and chemicals. The x-rays can also be shared easily both with veterinary specialists and with owners.

Computed tomography (CT) scans use x-ray technology that moves in a circle around the structure of interest. For elbows and hips, this enables the production of 3-dimensional images of the structures of those joints, including the bones, cartilage and muscles.

This is particularly important in regards to changes that appear to be within the joint on a standard x-ray but where there is question of whether the change may actually be outside of the joint or variants of normal elbow structure not associated with elbow dysplasia. For example, an osteophyte is a bony projection that is often seen with arthritis and is a component of elbow dysplasia but mineralization/calcification around that joint (periarticular mineralization) can be seen on radiographs and some experts do not consider periarticular mineralization to be a component of elbow dysplasia (5). In a 2014 study of 46 elbows graded as 0 (normal) or grade 1 elbow dysplasia, 20% of the radiographs had proliferation on the anconeal process, sometimes called an anconeal bump (Figure 3), but had no other evidence of elbow dysplasia or arthritis (12). CT scans provided 3-dimensional information that the anconeal bump in dogs in the study was consistently in the same spot on the lateral aspect of anconeal process suggesting the possibility that the anconeal bump could be a condition of the connections between the anconeal process and the ligaments and tendons attached to it or of the joint capsule itself (12). While a small study, the study demonstrates the importance of CT scans in identifying the actual location of abnormalities in the canine elbow. It raised the question of why the proliferation would be located in a specific spot in most dogs if the proliferation was due to arthritis. Hopefully, future larger studies will identify the underlying condition creating the anconeal bump and other abnormalities of the elbow joint and their relationship to elbow dysplasia.

A 2022 study used CT scans to investigate the actual location within the joint of damage associated with mild, moderate, or severe elbow arthritis in 20 dogs (22). The study also compared CT scans with plain x-rays. That study demonstrated that on both CT scans and plain radiographs, changes in the anconeal process and the coronoid process (Figure 3) were among the more common locations of abnormality in dogs with elbow arthritis both on CT scans and on plain radiographs (22). The study also demonstrated that traditional x-ray findings correlated well with CT scans. However, neither of the two recent studies identify what tissue creates the x-ray image identified as an anconeal bump (12; 22).

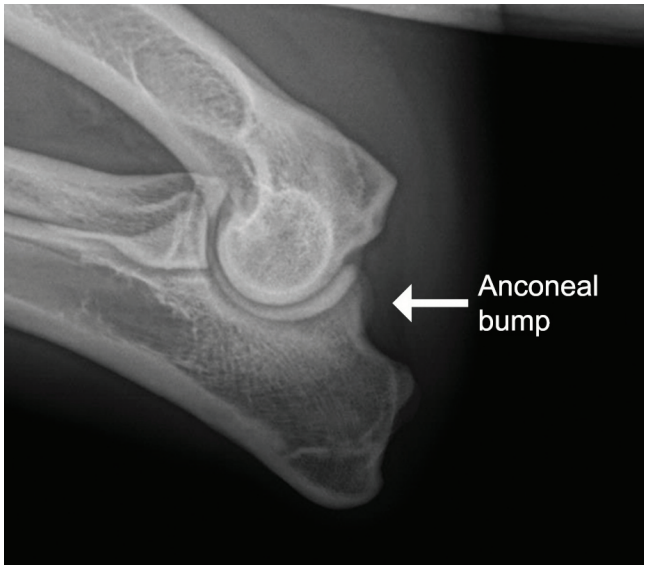

Figure 3. X-ray of the elbow of a Golden Retriever diagnosed with grade 1 elbow dysplasia due to an anconeal bump, that is indicated by the fuzzy outline at the margin of the anconeal process.

In summary, multiple studies indicate that plain radiographs are very useful for screening for hip and elbow dysplasia. Digital radiology has improved the ability of veterinarians and owners to receive copies and understand the changes revealed by the x-rays. For elbow dysplasia, CT scans can provide additional information (and expense) about subtle abnormalities seen on regular x-rays and in identifying lesions in clinical cases without a specific diagnosis on plain x-rays. This can be helpful in managing dogs with lameness and may be helpful in appealing some cases of elbow dysplasia diagnosed using plain x-rays alone (5; 12; 22).

DNA testing

Health evaluations by veterinary specialists remain the cornerstone for selecting Golden Retrievers with a reduced risk for elbow dysplasia and hip dysplasia. A large number of genes as well as environmental factors play roles in risk for these disorders (16). However, it is important to know the limits of what we know today. Currently, scientists have identified the function of only a small percentage of canine genes and know even less about the regulators that control these genes (20). In short, no DNA test or DNA panel is currently accepted by the veterinary community as useful in improving rates of hip or elbow dysplasia in Golden Retrievers. Even if DNA tests become available for some genes that contribute to hip and elbow dysplasia, it is highly unlikely we will have DNA tests for all genes that can contribute to hip and elbow dysplasia. For this reason, GRCA guidelines for screening Golden Retrievers breeding dogs for hip, elbow, eye and heart disease all include phenotypic evaluation by veterinary specialists (6).

However, the incidence of hip and elbow dysplasia varies between different bloodlines and bloodlines vary between and within countries. For example, the incidence of elbow dysplasia in New Zealand Golden Retrievers in 2008 was reported to be 77% (35). In contrast, the incidence of elbow dysplasia in Golden Retrievers evaluated by OFA (predominantly North American Golden Retrievers) between 2006 and 2010 was 10.3% (Table 4). However, an eye disease that can cause blindness, pigmentary uveitis, is common in North American Golden Retriever bloodlines but rarely reported in some other parts of the world (29; 30). Situations like this create challenges for breeders who are trying to bring in bloodlines that will improve the health of Golden Retrievers in their breeding program.

Where DNA testing can help is by enabling inclusion into breeding programs of Goldens with outstanding production records for sound hips and elbows but who are carriers of recessive diseases for which DNA tests exist. For example, it would be entirely possible to use a Golden Retriever with an outstanding hip and elbow production record who was a carrier for the eye disease GR_PRA1 as long as the mate(s) were normal/clear for GR_PRA1 (6). Similarly, the worldwide success in reducing hip and elbow dysplasia, means that hip and elbow information on individual dogs and their close relatives should be available when seeking an outcross Golden Retriever from another country, although there will be nuances in how the screening tests are done in other countries.

	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020	≥2021
ELBOW - NORMAL	85.9	89.0	89.5	87.7	88.0	86.0
ELBOW - ALL DYSPLASTIC	13.7	11.0	10.3	12.2	11.9	14.0
ELBOW - GRADE 1	7.6	8.6	7.7	8.6	9.0	8.8
ELBOW - GRADE 2	1.5	1.7	1.6	2.3	2.0	3.5
ELBOW - GRADE 3	.5	.2	.3	.4	.2	.0

Table 4: Elbow dysplasia percentages in Golden Retrievers evaluated by OFA over the years.[1,2]

[1]Data are from the OFA and were downloaded 2/4/2023

[2]The pandemic caused major staffing shortages for the veterinary profession in the US (33). Data in 2021 and after may reflect changes associated with the pandemic regarding dogs whose radiographs were submitted, the veterinarians submitting radiographs to the OFA, and the radiologists evaluating the films.

Conclusion

For many years, breeders and the veterinary community have worked together to reduce the risk of hip and elbow dysplasia in Golden Retrievers produced by conscientious breeders. This is a worldwide effort to produce dogs with a better quality of life. The screening procedures vary in different countries but improvement has been documented in many countries. In the future, modern techniques such as computed tomography (CT), calculation of EBVs, and genetic testing may facilitate improvement but radiographic screening to identify healthy joint structure remains essential to breed health. Thus, we can reach the goal of producing high quality Golden Retrievers that with each passing generation have improved odds for living long healthy lives. Sound hips and elbows are among the many traits important in reaching that goal.

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