# Quantification of sclerosis of the ulnar trochlear notch in dogs with fragmentation of the medial coronoid process

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**Abstract**

The aim in this study was to make a quantification of sclerosis of the ulnar trochlear notch in dogs with fragmentation of the medial coronoid process. On this moment it is difficult to diagnose FCP on radiographs alone. In practice it could be useful to diagnose FCP only on radiographs, because this method is widely used in practice.
There is proven that sclerosis is more present in elbows positive for FCP. It seems that the sclerosis plays an important role in elbows positive for FCP.
The sclerosis in this study is assessed on density and expand. We used two methods derived from Proks et al. 2010 and from Smith et al. 2009 to make this quantification. In this study was the main cause to conclude if this methods could be used in the diagnosis of FCP in individual dogs.
There is a difference between healthy and FCP elbows in density and expand. On this moment the methods used in this study cannot be used in the individual patient, but maybe they could be used in future.

**Introduction**

In dogs, elbow dysplasia is a common syndrome in which one or more of the following conditions is present: fragmentation of the medial coronoid process of the ulna (FCP), osteochondrosis/osteochondritis dissecans (OCD) of the medial part of the humeral trochlea, ununited anconeal process (UAP), and incongruity of the elbow joint (INC).[19,13] Elbow dysplasia occurs mostly in young, medium to large-sized dogs, and may lead to osteoarthrosis and lameness.[13, 17,20] The most frequently occurring developmental disease of the elbow in dogs is FCP.[14, 9]
The two main hypotheses for the occurrence of FCP are abnormal endochondral ossification and abnormal mechanical forces.[19] Joint incongruency is one of the mechanisms that could lead to FCP, but it is not present in all cases of FCP.[10, 11]
For the diagnosis of FCP radiography, [1, 4, 5, 7, 8, 13, 14, 16-18, 20] arthroscopy,[2,5,8,14-16,18], computed tomography (CT),[2,12, 15] magnetic resonance imaging (MRI),[17] and scintigraphy[3] have been used. Radiography is the most frequently used diagnostic tool in general practice, but it is a challenge to base the diagnosis FCP on survey radiographs alone.[10, 17] In association with elbow dysplasia periarticular osteophytosis, subluxation of the humeroulnar joint and trochlear sclerosis of the semilunar notch of the ulna may be found radiographically.[1, 6]
Most prevalent signs on CT are periarticular osteophytes (97 per cent) subchondral sclerosis affecting the MCP (86 per cent) humerus (84 per cent) or ulna (62 per cent) and fragmentation (62 per cent(NB: wat was hier de gouden standaard?)).[12] Scintigraphy was used for the diagnosis of abnormalities of the MCP in dogs, especially in older dogs where clinical and radiographic changes can be ambiguous.[3]
In Labrador retrievers an increase in radiopacity throughout the majorpart of the ulnar trochlear notch region was found on radiographs in dogs with FCP.[4] This sclerosis may be an important indicator for the presence of FCP.[4, 13] The speculation is that the increase in ulnar trochlear radiopacity most likely occurs because of a combination of superimposition of periarticular osteophytes and bone sclerosis.[4] In the study Burton et al 2008 proved that there

is an inconsistency between observers in their ability to differentiate between elbow joints with an increase in ulnar trochlear notch sclerosis and normal elbows.[6] Also they concluded that observer sensitivity for trochlear sclerosis is 72% and the specificity is 22%, this means that observer grading is not reliable.[6] Others demonstrated that the elbow joints with proven FCP had a lower mean median optical density in the distal part of the incisura trochlearis compared to healthy elbow joints.[16] This lower optical density in dogs with FCP is probably in the distal segment of the trochlear ulnar notch.[16] This region with a lower optical density was also earlier found in the study of Burton et al. 2007.[4] The region with the biggest difference in pixel intensity in healthy elbows and elbows diagnosed for FCP in the study of Burton et al. 2007 was the proximal segment of the distal part of the trochlear ulnar notch in the region of the base of the MCP.[4] This result was not in agreement with the study of Proks et al, they found the medial and distal third of the trochlear ulnar notch, in regions more distant from the articular surface as the region with the biggest difference in pixel intensity between healthy elbows and elbows diagnosed for FCP.[16] This could be related to the difference in method that was used.[16] The aim of the present study was to more objectively quantify of the sclerosis on the ulnar trochlear notch.

## Materials and methods

The digital archive of the division of Diagnostic Imaging, Faculty of Veterinary Medicine, Utrecht University, was reviewed over a 3-year period and 39 dogs were identified of which CT and radiographs of both elbow joints were available.
Twenty-five of these dogs were referred with front limb lameness and the remaining 14 dogs were clinically sound and examined for screening purposes.
Age, sex, body weight and breed of the dogs were recorded.

All radiographs (ML90° flexed, ML extended, CrCd, CrL-CdMO) were evaluated for the grade of arthrosis, using the protocol of the IEWG.[21, 22]

On all ML radiographs the percentage subtrochlear sclerosis (%STS) was measured as described by Smith et al.(2009)[18]
To measure %STS (Figure 1) a line was drawn perpendicular to the most caudal margin of the ulnar proximal metaphyseal cortex (point 1) and to the most proximocaudal aspect of the radial head (point 2).[18] The STS caudal border (point 3) which constituted a subjective radiographic assessment of the junction between sclerotic and normal trabecular bone pattern, was created along line α-β, point δ. The distance 2-3 (X) was expressed as a percentage of the total distance 1-2 (Y). The %STS was calculated as 100(X/Y).[18] Elbows without STS were scored as 0%.


Figure. 1

The program JiveX was used to measure the averaged pixel intensity of the sclerotic region of the ulnar trochlear notch. The use of JiveX for this purpose has been described.[16] Averaged pixel intensity was used to measure the optical density of the sclerotic region of the ulnar trochlear notch.

Averaged pixel intensity was measured in the sclerotic region on the trochlear notch. First a line was drawn parallel on the cortex, this was line A. Then line B was drawn from line A with an angle of 90° to the point of the lateral medial coronoid process. Line C was drawn so there arises a triangle in the MCP. Beside the place where line B and line C crossed a circle with a diameter of 4,0 mm was drawn. Above line B in the cortex, the averaged pixel intensity of the cortex was measured also in a circle with a width of 4,0 mm (fig. 2).

Figuur 2

When all measurements were sampled, the optical density was calculated (average pixel intensity sclerosis/average pixel intensity cortex).

The radiographs made in DR were separated from the radiographs made in CR in the results. There were 52 elbows in the DR group and 26 elbows in the CR group.

After evaluation of the radiographs another observer evaluated the CT-scans. The CT-scans were diagnosed for FCP. All CT-scans were diagnosed positive or negative for FCP.

The statistical analysis of the %STS and the S/C ratio was done with a mixed model

## Results

Of 39 dogs in this study 14 were Labrador retrievers, 9 cross-breed Labrador retrievers, 2 Rottweilers, 2 German sheperds, 1 flatcoated retriever, 1 great Dane, 1 tatra dog, 1 tosa inu, 1 American bulldog, 1 Tibetan mastiff, 1 bullmastiff, 1 white shepherd, 1 German pointer, 1 cross-breed shepherd, 1 cross-breed golden retriever, 1 mastiff. The average body weight of the dogs was 35,33 kg (range 14,5 to 74,5 kg). The average age of the dogs was 28.7 months (range 6 to 118 months). There were 28 males (23 in tact, 5 castrated) and 11 females (6 in tact, 5 castrated). On CT there were 46 positive FCP elbows and 32 negative FCP elbows. Of the positive FCP elbows 25 had arthrosis grade 0, 13 grade 1, 7 grade 2 and 1 had grade 3. Of the negative FCP elbows 21 had artrhosis grade 0, 4 grade 1 and 7 grade 2.

In the DR group 33 elbows were positive for FCP and 19 were negative. In the positive FCP group 25 elbows were rated positive by visual assessment of the sclerosis and 8 were negative. In the negative FCP group were 2 elbows positive on visual assessment for sclerosis and 17 were negative. In the CR group 13 elbows were positive for FCP and 13 were negative. In the positive FCP group 13 elbows were rated positive by the visual assessment of the sclerosis and 0 were negative. In the negative FCP group were 5 elbows positive for sclerosis and 8 were negative (table 1).

| | **DR** | **CR** |
|---|---|---|
| **Total** | 52 | 26 |

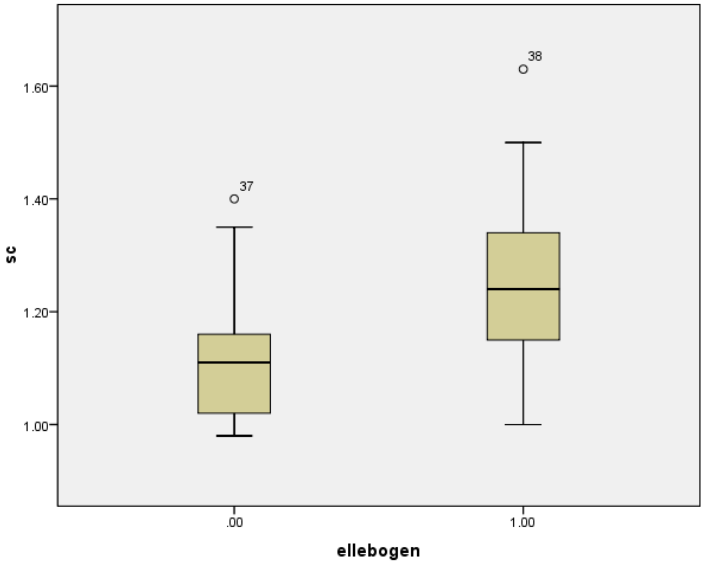
| CT | 33 positive FCP | | 19 negative FCP | | 13 positive FCP | | 13 negative FCP | |
|---|---|---|---|---|---|---|---|---|
| **Visual sclerosis assessment** | 25 positive | 8 negative | 2 positive | 17 negative | 13 positive | 0 negative | 5 positive | 8 negative |

Table 1.

The average sclerosis/cortex (S/C) ratio in the DR group in the positive FCP elbows was 1.26 (range 1-1.63) and in the negative FCP elbows 1.12 (range 0.98-1.35). The average %STS in de DR group was in the positive FCP elbows 34.30 (range 0-60) and in the negative elbows 3.48 (range 0-43.17. The average S/C ratio in the CR group in the positive FCP elbows 0.91 (range 0.82-1,06) and in the negative FCP elbows 0.93 (range 0.89-0.98). The average %STS in the CR group in the positive FCP elbows 48.42 (range 39.78-57.23) and in the negative FCP elbows 19.81 (range 0-57,5) (table 2).

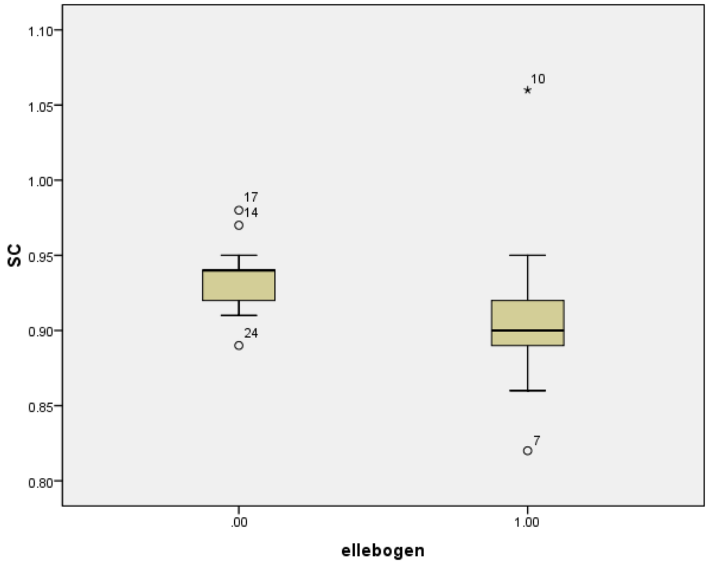
| | **DR** | | **CR** | |
|---|---|---|---|---|
| **Total** | 52 | | 26 | |
| **CT** | 33 positive FCP | 19 negative FCP | 13 positive FCP | 13 negative FCP |
| **S/C** | 1.26 | 1.12 | 0.91 | 0.93 |
| **%STS** | 34.30 | 3.48 | 48.42 | 19.81 |

Table 2.

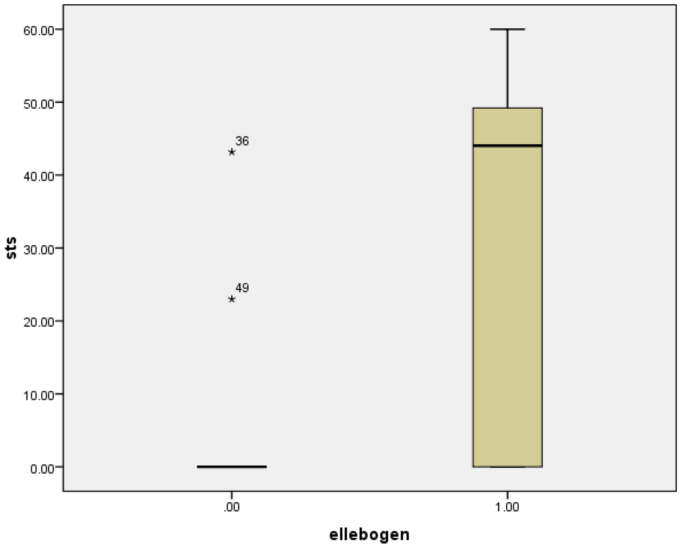



Graph 1a

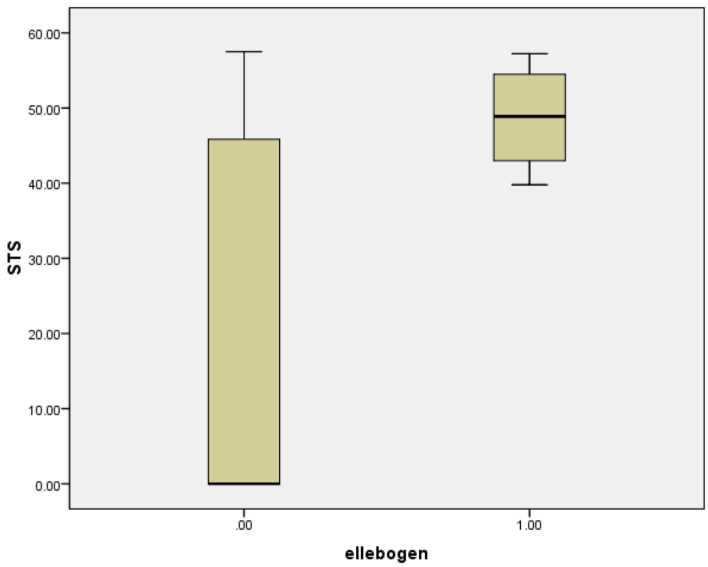
Distribution of the S/C value of the DR group between healthy and positive FCP elbows. 0.00 are elbows negative for FCP and 1.00 are the elbows positive for FCP.




*Graph 1b.*
Distribution of the S/C value of the CR group between healthy and positive FCP elbows. 0.00 are the elbows negative for FCP and 1.00 are the elbows positive for FCP




Graph 2a.
Distribution of the STS in the DR group between healthy and elbows positive for FCP. 0.00 are the healthy elbows and 1.00 are the elbows positive for FCP.




Graph 2b.
Distribution of the STS in the CR group between healthy and elbows positive for FCP. 0.00 are the healthy elbows and 1.00 are the elbows positive for FCP.

Only in the DR group in the S/C ratio between the negative FCP elbows and positive FCP elbows was a significant difference with a p-value < 0.000. In the CR group in the S/C ratio between the positive and negative elbows for FCP was no significant difference. In both groups between the positive FCP elbows and negative FCP elbows in the %STS measurement was no significant difference.

## Discussion

In this study the ML views were used for visual assessment and measurement of sclerosis, because in this views the changes in optical density of the ulnar trochlear notch in the distal part of the trochlear notch were best evaluated.[1] All views were used to grade the elbows for arhtrosis.

In table 1 is seen that in both groups in the visual sclerosis assessment more elbows were positive for visual sclerosis when they were positive for FCP on CT. In both groups elbows negative for FCP, are more elbows negative for sclerosis, but there were also a few elbows that were positive for sclerosis and negative for FCP. This results are not in agreement in our expectation. We expected that the elbows positive for FCP only were positive for sclerosis, and not that the elbows negative for FCP were positive for sclerosis. The results were in agreement with the results found in the study of Smith et al. 2009.[18] In that study they found also elbows that were positive for sclerosis but negative for FCP in arthroscopy and elbows negative for sclerosis and positive for FCP in arthroscopy.[18] Based on this results we can conclude that sclerosis is more present in elbows positive for FCP, but it's not present in all positive FCP elbows. In some cases the sclerosis is present in elbows that are not negative for FCP. If sclerosis is present in a elbow, there may be not concluded that the elbow is positive for FCP. Besides it sclerosis is not present in all elbows positive for FCP and absent in elbows negative for FCP. The visual assessment of sclerosis is also very subjective. In conclusion the visual sclerosis assessment may not only be used in the individual patient for the diagnosis of FCP.

The results of the DR and CR group were separated in this study. This was because there was a difference in measuring the pixel intensity in DR and CR radiographs.

Between the group of elbows positive for FCP and the control group of healthy elbows were found a highly significant difference in optical density of the trochlear notch of the ulna in the study of Proks et al 2010.[16] There was a lower optical density in elbows with FCP in the distal segment of the trochlear ulnar notch.[16] These results were in agreement with the study of Burton et al. 2007 and the subjective evaluation in the study of Berry 1992.[16] They were not in agreement with the study of Burton et al 2010.[5] In that study they found a decrease of bone mineral density in dogs that are positive for FCP.[5] The reason why this is contradicting is poorly understood.
In the present study a method was used derived from Proks et al. 2010. They considered the different sizes of the regions of interest they used a weak point in their study and therefore a smaller but continuous identical ROI was used in the present study
In the DR group we found an average S/C ratio of 1.26 in the elbows positive for FCP and an average S/C ratio of 1.12 in healthy elbows. In the CR group we found an average S/C ratio of 0.91 in the elbows positive for FCP and of 0.93 in healthy elbows. In the DR group the positive FCP elbows have an higher S/C ratio compared to the healthy elbows, because the white parts in the radiographs had an higher pixel intensity. In the CR group the positive FCP elbows have a lower S/C ratio compared to the healthy elbows, because the black parts in the radiographs had an higher pixel intensity.
In the S/C ratio there is no distinct difference between healthy elbows and elbows positive for FCP, this is also seen in graph 1. There is no boundary between the positive and negative FCP elbows. Based on this result we can conclude that for the individual patient this method cannot be used to determine the presence or absence of FCP in elbows.
In the DR Group there was a significant difference with $p < 0.000$ in S/C ratio between the negative FCP elbows and the positive FCP elbows. In the CR group there was no significant difference between the negative and positive FCP elbows.

The study of Smith et al 2009 concluded that the elbow position has no significant effect on the %STST score.[18] So in our study it is justified that we used the medio-lateral 90° flexed view of the elbow instead of the medio-lateral flexed view that was used in Smith et al 2009. Measuring the %STS was quick and very easy to perform, this was also concluded in Smith et al. 2009.[18] In Smith et al 2009 they hypothesized that scoring STS as a percentage would

allow comparison between elbows of different sizes and in this way comparison of elbows from different breeds.[18] In the study of Smith et al 2009 the %STS of elbows positive for FCP were median 47% (range 0-74%) and 0% (range 0-62%) for the control elbows.[18] In this study the average %STS in the DR group was 34.30 (range 0-60%) in the elbows positive for FCP and the average %STS was 3.48 (range 0-43.17) for the control elbows. In the CR group the average %STS was 48.42 (range 39.78-57.23) in the elbows positive for FCP and the average %STS in the control elbows was 19.81 (range 0-57,5). In both study's there is no distinct difference in the healthy elbows and the elbows positive for FCP. This is also seen in graph 2, there is no boundary between the positive and negative elbows for FCP.
In this study there was not found a significant difference between the negative FCP elbows and the positive FCP elbows.
Based on the results in our study this means that when there is a %STS value, there may not be concluded if the elbow is positive or negative for FCP, more diagnostic tools are needed. When measuring the %STS, first there has to be concluded if the elbow is positive or negative for sclerosis, so on this moment this method is not objective. There is more research needed to determine if this method could be used in the diagnosis of FCP, this is also concluded in the study of Smith et al 2009.[18]

Prominent in the present study is that some results are contradicting. Some elbows with a subjective positive sclerosis assessment have a low S/C ratio in the DR group and a high S/C ratio in the CR group. We expected that the elbows with a positive sclerosis assessment would have a higher S/C ratio in the DR group and a lower S/C ratio in the CR group. This was only present in a few elbows. One reason of this contradicting result could be that the measurements in JiveX were not reliable.
The lower optical density of the trochlear notch of the ulna in dysplastic elbows is probably caused by thickening of bone trabecules, subchondral sclerosis and formation of periarticular osteophytes/enthesophytes along the medial border of the trochlear notch of the ulna.[4] It is not explaining the reason for positive sclerosis and a low S/C ratio in the DR group and a high S/C ratio in the CR group. A description of this phenomenon was not found in the literature and is poorly understood.

From the present study it is concluded that none of the described methods can be used isolated for the diagnosis of FCP in the individual patient. The role of sclerosis in elbows with FCP is still poorly understood and more research is needed to clarify the relation between trochlear notch sclerosis and FCP.

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