4. Evaluation of the joint space of Canine Elbow Dysplasia by using reconstructed computer tomography

4.1 Dogs

One hundred and thirty-six elbow joints of sixty-eight dogs were examined by computer tomography during 2004-2006 at the Clinic of Small Domestic Animals, Free University of Berlin. To be included each dog had to have adequately documented clinical records, and a complete computer tomography study of both elbow joints. Fifty-seven joints were in the normal group. Seventy-nine joints were affected joints. Twenty-six dogs were affected bilaterally. Forty-two joints were affected only on the left, and thirty-seven joints had lesions only on the right side.

4.2 CT examination

Dogs were sedated with Midazolam (0.05 mg/kg) and then anesthetized with 0.3 mg/kg Propofol (Narcofol) via intravenous injection, and maintained with Isofluran (1 to 2 percent). CT scans of the elbow were obtained using the third-generation CT scanner (GE light speed). The elbows were scanned in pairs and placed in dorsal recumbency and elbows were in slight extension. The region to be scanned was identified using an initial craniocaudal scout projection and included the entire elbow articulation distal to the coronoid process. This region of interest was scanned with sequential slices at 1.0 mm intervals, slice thickness was 1.25 mm. Reconstructions were made by using a bone setting (window width 2000 Hounsfield units, window level 350 Hounsfield units). The images were analyzed by GE work station version 4. The different CT images were reconstructed in multiple anatomical planes to measure joint space between humero-radial and humero-ulnar joint. Elbows were assigned to either an FMCP group or a normal group.

4.3 Method of measurement

The transverse CT slice through the most cranial aspect of the medial coronoid process (the apex of the coronoid process) was identified. Using image analysis tools, three-position measurements of the radio-ulnar joint space on transverse CT slice were obtained. The measuring positions were 3.0, 6.0 and 9.0 mm caudal to the coronoid apex. In the event of identification of a coronoid fragment on the transverse CT slice, the measuring positions were 3.0, 6.0 and 9.0 mm caudal to the fissure line. By analysing sagittal plane, we use transverse CT slice as a template. From this slice, the sagittal plane reconstructed was formatted at 90^{o} to the long axis of the coronoid apex. Using image analysis tools, joint spaces between humero-radial (HR) and humero-ulnar (HU) were measured at 3.0, 6.0 and 9.0 mm caudally from coronoid apex or fissure line respectively. Coronal plane was reconstructed by cross-sectional 180^{o} long axis of transverse CT slice. Humero-radial and humero-ulnar joint space measurements were obtained at 3.0, 6.0 and 9.0 mm caudally from coronoid apex or fissure line respectively.

A

B

Fig. 38 The measurement method
(A) By analysing coronal plane, we use transverse CT slice as a template. Joint spaces between humero-radial (HR) and humero-ulnar (HU) were measured at 3.0, 6.0 and 9.0 mm caudally from coronoid apex or fissure line respectively.
(B) Sagittal plane were reconstructed by cross sectional 180^{o} long axis of transverse CT slice. Humero-radial and humero-ulnar joint space measurement were obtained at 3.0, 6.0 and 9.0 mm caudally from coronoid apex or fissure line respectively.

4.4 Statistical analyses

Data were statistically analyzed using an available statistical computer package. Data of joint space measurements were tested for normal distribution by using the Kolmogorov-Smirnov test. For each level of reconstruction, the values of joint space of FMCP and the normal group were compared by using the Mann-Whitney U test. Agreements for each value of different joint levels within the FMCP group were assessed graphically and using Spearman's rank order correlation test.

4.5 Results

Seventy-nine FMCP and fifty-seven normal elbows were recognized. On sagittal plane, the mean value of joint space between humero-radial of the normal group is 0.87 mm, and of the FMCP group it is 0.94-1.00 mm. The mean value of joint space between humero-ulnar of the normal group is 0.83-0.87 and of the FMCP group it is 1.00-1.08 mm.

The study showed that the humero-radial joint space(HR sagittal) on sagittal plane has significant difference ($p < 0.001$) between disease and normal group at 0.3 mm caudally from coronoid apex, while humero-ulnar joint spaces (HU sagittal) had significant difference between normal and disease group in all position where we measured.

From coronal plane, the mean value of humero-radial joint space (HR coronal) of the normal group is 0.93 mm. and of the disease group 0.97 mm. The mean value of humero-ulnar joint space (HU coronal) of the normal group is 0.93 and of the disease group is 0.94. Statistically evaluated, both of them had no significant difference between disease and normal group.

Table 8: Joint-space measurements for comparison of computed tomography images (millimeters)

item	Normal		disease		Sig.
	N	**Mean ± SD**	**N**	**Mean ± SD**	
HR sagittal 1	***57***	***0.87 ± 0.20***	***79***	***1.00 ± 0.27***	***
HR sagittal 2	57	0.87 ± 0.21	79	0.94 ± 0.30	**NS**
HR sagittal 3	57	0.88 ± 0.21	79	0.95 ± 0.31	**NS**
HU sagittal 1	***57***	***0.87 ± 0.25***	***79***	***1.08 ± 0.49***	*
HU sagittal 2	***57***	***0.84 ± 0.24***	***79***	***1.03 ± 0.41***	***
HU sagittal 3	***57***	***0.83 ± 0.23***	***79***	***1.00 ± 0.39***	***
HR coronal 1	57	0.96 ± 0.26	79	1.01 ± 0.32	**NS**
HR coronal 2	55	0.91 ± 0.26	76	0.97 ± 0.29	**NS**
HR coronal 3	53	0.93 ± 0.24	75	0.97 ± 0.28	**NS**
HU coronal 1	57	0.94 ± 0.26	78	0.97 ± 0.27	**NS**
HU coronal 2	55	0.93 ± 0.28	77	0.94 ± 0.27	**NS**
HU coronal 3	53	0.92 ± .25	75	0.92 ± 0.22	**NS**

Significance is indicated with *p < 0.05, **p < 0.01 and ***p < 0.001.

Fig. 39 CT images in sagittal plane of a 3-year-old Labrador's elbow with severe Elbow Incongruence and fragmented coronoid process
(A) The right side of elbow joint presented wide humero-radial joint space
(B) The left side of elbow joint presented narrow humero-ulna joint space

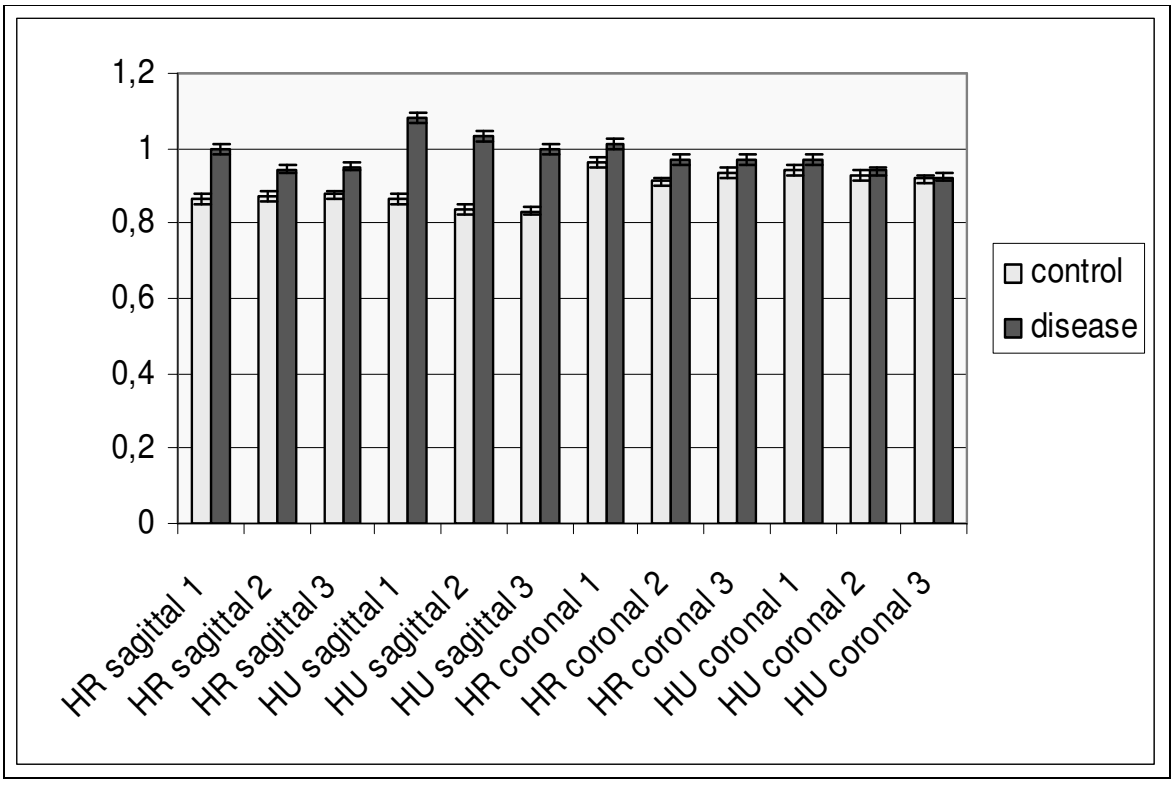

Fig. 40 The mean value of joint space between humero-ulnar on sagittal plane (HU sagittal) humero-radial on sagittal plane (HR sagittal) and humero-radial (HR coronal) and humero-ulna (HU coronal) on coronal plane of computed tomography images of normal group and disease group were measured for comparison.

4.6 Inter-image variation analysis

Measurements from different positions of the same elbows show good agreement (Table 9) between humero-ulnar joint spaces in sagittal plane. Correlation from Spearman's rank order correlation test was ranging from 0.70 to 0.80. The mean variation between data points was 0.40 mm.

	HR sagittal 1	HR sagittal 2	HR sagittal 3	HU sagittal 1	HU sagittal 2	HU sagittal 3	HR coronal 1	HR coronal 2	HR coronal 3	HU coronal 1	HU coronal 2	HU coronal 3
HR sagittal 1	1											
HR sagittal 2	.696(**)	1										
HR sagittal 3	.697(**)	***.742(**)***	1									
HU sagittal 1	.657(**)	.621(**)	.589(**)	***1***								
HU sagittal 2	.695(**)	.622(**)	.598(**)	***.809(**)***	***1***							
HU sagittal 3	***.709(**)***	.623(**)	.666(**)	***.728(**)***	***.758(**)***	***1***						
HR coronal 1	***.705(**)***	.651(**)	.640(**)	.593(**)	.585(**)	.629(**)	1					
HR coronal 2	.561(**)	.620(**)	.545(**)	.503(**)	.504(**)	.531(**)	.665(**)	1				
HR coronal 3	.581(**)	.609(**)	.544(**)	.461(**)	.449(**)	.483(**)	.624(**)	.728(**)	1			
HU coronal 1	.542(**)	.559(**)	.464(**)	.445(**)	.457(**)	.511(**)	.596(**)	.519(**)	.470(**)	1		
HU coronal 2	.529(**)	.536(**)	.463(**)	.484(**)	.457(**)	.458(**)	.565(**)	.647(**)	.516(**)	.656(**)	1	
HU coronal 3	.551(**)	.559(**)	.493(**)	.376(**)	.391(**)	.409(**)	.532(**)	.602(**)	.634(**)	.609(**)	.686(**)	1

Table 9: Correlation matrixes within humero-ulnar (HU sagittal), humero-radial on sagittal plane (HR sagittal) and humero-radial (HR coronal), humero-ulnar (HU coronal) on coronal plane of computed tomography images (in millimeters)