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Comparison of Mandibular Measurements Using 3D Scanner and Computed Tomography Methods in New Zealand Rabbits

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ABSTRACT The aim of the study is to perform morphometric analyses on the mandibles of New Zealand rabbits using different measurement methods and to compare these methods. In this context, the mandibles of 6 female and 6 male New Zealand rabbits were used in the study. Computed tomography (CT) cross-sectional images of the animals were taken and a three-dimensional model of the mandible was obtained from the two-dimensional images using the MIMICS medical software. In addition, the mandibles were modeled in 3D using a 3D scanner. Length measurements were made on the obtained 3D model and statistical analyses of these data were provided. When the measurements taken with the CT and 3D scanner methods were compared, it was observed that the two measurement methods were compatible with each other. As a result, the measurements taken with the 3D scanner and CT were compared and similar results were obtained with both methods. It is thought that this result will be a resource for researchers working on experimental mandibular surgery in rabbits and that taking measurements with a 3D scanner has more advantages than the CT device in terms of morphometric measurement, higher detail and surface scanning. The CT device is advantageous because it scans the entire tissue and gives very fast results. As a result, using both methods together are thought to be advantageous for researchers.

Keywords: *Computed Tomography, Mandible, Rabbit, Three-Dimensional scanner.*

ÖZ

Yeni Zelanda Tavşanlarının 3D Tarayıcı ve Bilgisayarlı Tomografi Yöntemleri Kullanılarak Yapılan Mandibular Ölçümlerinin Karşılaştırılması

Çalışmanın amacı, Yeni Zelanda tavşanlarının mandibula'ları üzerinde farklı ölçüm yöntemleriyle morfometrik analizler yapmak ve bu yöntemleri karşılaştırmaktır. Bu doğrultuda, çalışmada 6 dişi ve 6 erkek ergin Yeni Zelanda Tavşanı mandibula'sı kullanılmıştır. Hayvanların bilgisayarlı tomografi (BT) kesit görüntüleri alınmış ve iki boyutlu görüntülerden MIMICS Medical yazılımı kullanılarak mandibula'nın üç boyutlu modeli elde edilmiştir. Ayrıca 3 boyutlu tarayıcı kullanılarak mandibulalar 3 boyutlu olarak modellenmesi gerçekleştirilmiştir. Elde edilen 3B model üzerinde uzunluk ölçümleri yapılmış ve bu verilerin istatistiksel analizleri sağlanmıştır. BT ve 3B tarayıcı yöntemleriyle alınan ölçümler karşılaştırıldığında, iki ölçüm yönteminin birbiriyle uyumlu olduğu gözlemlenmiştir. Sonuç olarak, 3 boyutlu tarayıcı ve BT ile yapılan ölçümler karşılaştırılmış ve her iki yöntemle de benzer sonuçlar elde edilmiştir. Bu sonucun tavşanlarda deneysel mandibular cerrahi üzerine çalışan araştırmacılar için bir kaynak olacağı ve 3B tarayıcı ile ölçüm almanın BT cihazına göre morfometrik ölçüm, daha yüksek detay ve yüzey tarama yönleri daha avantajlıdır. BT cihazı dokuların tamamını taradığı için ve çok hızlı sonuç verdiği için avantajlı olmaktadır. Sonuç olarak çalışmada kullanılan yöntemlerin birlikte ve koordineli olarak kullanılmasının araştırmacılar için avantajlı olacağı düşünülmektedir.

Anahtar Kelimeler: *Bilgisayarlı Tomografi, Mandibula, Tavşan, Üç boyutlu tarayıcı.*

INTRODUCTION

The animals most commonly used as experimental models today are mice, rats, rabbits, and guinea pigs (Mukherjee et al. 2022). Animal experiments are often a necessary step in developing treatments applicable to humans, with various animals serving as experimental models in this process. Rabbits are one of the most frequently used models for studying bone remodeling or jaw surgery. They are preferred in experiments due to their docile nature,

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cleanliness, lower zoonotic risk compared to other animals, and quiet behavior. It is possible to find rabbits of the same breed, weight, and gender, and even individuals with specific degrees of kinship. Their ease of care also makes them ideal for laboratory studies (Yücetürk 1980; Neyt et al. 1998; Cooper et al. 2021). One of the primary advantages of rabbits is that they reach skeletal maturity shortly after reaching sexual maturity at six months of age (Akbulut et al. 2014; Campillo et al. 2014). The most commonly used breed of rabbit in laboratories is the New Zealand rabbit (Brewer 2006; Burkholder et al. 2012). Studies have indicated that the mandibular region contains several clinically significant points essential for regional anesthesia in animals, and the rabbit mandible, in particular, has been used as an experimental model in invasive applications such as dentistry and implants (Karimi et al. 2012; Schlund et al. 2022; Kim et al. 2023). Computed tomography and 3D scanners are frequently used in the field of veterinary anatomy. In recent years, the number of studies has increased and contributed to this field (Demircioğlu et al. 2021; Koçyiğit and Demircioğlu 2024). The aim of this study was to determine whether there is a difference between mandibular data obtained from computed tomography and 3D scanner and to investigate the method compatibility.

MATERIAL AND METHODS

In this study, 6 female and 6 male adult New Zealand rabbits were used. Ethical approval for the study was obtained from the Harran University Animal Experiments Local Ethics Committee decision dated 16/10/2024 (Decision No: 2024/006/08). After being subjected to maceration (Taşbaş 1965), the mandibles forming the study material were scanned and craniometric measurements were taken using a 3D scanner. The scanning was performed with a 3D EinScan Pro 2X (2020) device, with each scan consisting of 18 images taken from different positions. The mandibles used in the study were scanned with a multi-slice spiral tomography device (Siemens Dual Source, Somatom Definition Flash, Germany). Imaging was conducted with parameters of 120 kV, 300 mA, 0.6 mm slice thickness, and a 515 x 512 matrix. Three-dimensional modeling and morphometric measurements (İnce and Pazvant 2010; Selçuk 2024) were performed using MIMICS Medical 21.0 software (Figure 1). SPSS and MedCalc software were used for statistical analysis. After checking the normal distribution of the data with the "Shapiro-Wilk test," gender differences were analyzed using the "Independent t-test." The compatibility of the methods was tested using the Bland-Altman analysis.

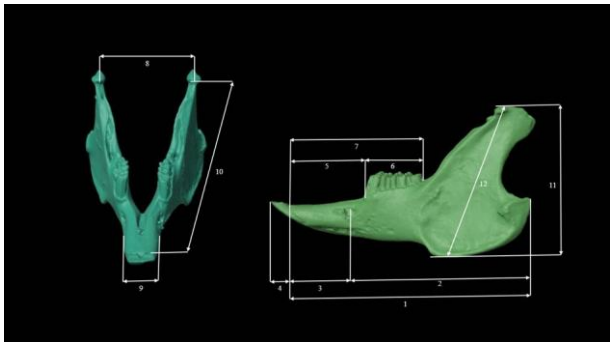

Figure 1: 1: Maximum length from the gonion caudale to the cranial border of the margo interalveolaris; 2: Length from the foramen mentale to the gonion caudale; 3: Distance between the infradentale and the foramen mentale; 4: Length from the infradentale to the end point of the mandibular incisors; 5: Diastema length; 6: Total length of the premolar and molar regions; 7: Distance from the infradentale to the alveolar border of the last molar; 8: Distance between the midpoints of the processus condylares; 9: Widest distance across the pars incisiva of the corpus mandibulae; 10: Distance between the infradentale and the cranial endpoint of the processus condylare; 11: Maximum height of the ramus mandibulae; 12: Maximum length between the processus condylare and the gonion ventrale.

RESULTS

The mandibular data of New Zealand rabbits scanned with the 3D scanner are presented in Table 1, while the data obtained from computed tomography scans are shown in Table 2. In the data scanned with the 3D scanner, it was found that the values of p1, p2, p4, p5, p6, p7, and p8 were higher in males. When the measured values were compared between males and females, no significant difference was found between the sexes ($p>0.05$). The Bland-Altman analysis applied to the measurement results obtained from the 3D scanner and computed tomography indicated that all data were within the limits of agreement, and no gender differences were observed in either measurement method.

Table 1: Mandibular Data Scanned with 3D Scanner.

Gender	Parameter	n	Min	Max	Mean	Std. Dev.	p
Female	1	6	62.87	66.47	64.519	1.405	0.367
Male	1	6	63.39	69.81	65.573	2.346	
Female	2	6	58.25	62.53	60.259	1.749	0.211
Male	2	6	59.82	65.6	61.729	2.052	
Female	3	6	16.08	21.57	18.478	1.847	0.994
Male	3	6	17.36	21.25	18.471	1.481	
Female	4	6	42.09	48.13	45.888	2.289	0.232
Male	4	6	46	48.71	47.204	1.090	
Female	5	6	19.88	22.21	21.291	0.849	0.610
Male	5	6	21.19	23.12	22.270	0.751	
Female	6	6	14.6	16.06	15.321	0.543	0.465
Male	6	6	14.93	16.64	15.572	0.601	
Female	7	6	35.09	38.38	36.417	1.269	0.097
Male	7	6	36.38	40.17	37.762	1.274	
Female	8	6	27.03	31.62	29.453	1.763	0.436
Male	8	6	27.11	32.37	30.293	1.823	
Female	9	6	9.5	10.64	10.126	0.481	0.949
Male	9	6	9.37	10.98	10.107	0.546	
Female	10	6	4.21	6.79	5.459	1.063	0.440
Male	10	6	3.58	5.67	5.029	0.757	
Female	11	6	36.82	40.17	38.510	1.305	0.200
Male	11	6	36.57	39.52	37.545	1.121	
Female	12	6	39.61	43.31	41.449	1.483	0.713
Male	12	6	39.9	42.52	41.161	1.131	

The data obtained from the 3D scanner in this study are presented in Table 1. No significant gender differences were found between males and females upon analysis.

Table 2: Mandibular Data Scanned with Computed Tomography.

Gender	Parameter	n	Min	Max	Mean	Std. Dev.	p
Female	1	6	62.93	69.85	65.317	2.470	0.436
Male	1	6	61.11	67.21	64.268	1.973	
Female	2	6	59.5	65.76	61.966	2.420	0.381
Male	2	6	58.04	63.63	60.807	1.932	
Female	3	6	13.85	21.97	18.077	3.016	0.680
Male	3	6	15.2	18.87	17.507	1.313	
Female	4	6	46.87	49.47	47.850	1.116	0.114
Male	4	6	44.08	47.68	46.647	1.288	
Female	5	6	21.16	25	23.136	1.376	0.539
Male	5	6	20.57	25.65	22.552	1.780	
Female	6	6	13.23	15.22	13.878	0.701	0.801
Male	6	6	13.06	14.46	13.969	0.494	
Female	7	6	34.52	3989	36.891	1.841	0.344
Male	7	6	34.43	37.72	35.952	1.403	
Female	8	6	29.94	32.81	31.301	1.216	0.710
Male	8	6	29.44	34.63	31.633	1.741	
Female	9	6	9.81	11.31	10.559	0.667	0.355
Male	9	6	9.86	12.01	10.992	0.864	
Female	10	6	4.4	5.82	4.957	0.516	0.784
Male	10	6	4.55	6.1	5.043	0.549	
Female	11	6	35.48	38.66	36.839	1.170	0.059
Male	11	6	36.96	40.49	38.378	1.314	
Female	12	6	39.62	43.61	41.507	1.384	0.593
Male	12	6	40.27	43.16	41.905	1.093	p

The measurements obtained from the three-dimensional mandibular models derived from computed tomography slices in this study are presented in Table 2. The analysis revealed no significant gender differences between males and females.

As a result of the data obtained in this study, 12 parameters were tested for method compatibility using Bland-Altman analysis (Figure 2). It was determined that all the parameters used in the study were within the limits of agreement, and the methods were found to be alternative to each other in terms of measurement.

DISCUSSION AND CONCLUSION

In a study conducted on New Zealand rabbits using a digital caliper (Akbulut et al. 2014), the average mandibular length was determined to be 66.62 mm in males and 66.15 mm in females. The height values were also found to be 44.87 mm in males and 44.82 mm in females. However, despite all measurements being higher in males, the difference between genders was not statistically significant ($p>0.05$). In our study, the average mandibular length measured with the 3D scanner was 65.573 ± 2.346 mm in males and 64.519 ± 1.405 mm in females. Similarly, the height values were 37.545 ± 1.121 mm in males and 38.510 ± 1.305 mm in females. No statistically significant difference was observed between genders in our study as well. These differences may be attributed to the measurement techniques used, the age of the animals, or genetic factors.

In a study using computed tomography (CT) on New Zealand rabbits (Selçuk 2024), it was reported that the distance between the molars was greater in females and the corona length of the mandibular tooth was greater in males, with these differences being statistically significant ($p<0.05$). However, in our study, no significant gender differences were found in any of the measurements ($p>0.05$). Selçuk (2024) study, the diastema length measured by CT in New Zealand rabbits was 20.470 ± 0.514 mm in males and 20.953 ± 0.422 mm in females. In our study, these values were measured as 22.552 ± 1.780 mm in male rabbits and 23.136 ± 1.376 mm in female rabbits.

In a study conducted on Wistar Albino rats (İnce and Pazvant 2010), a statistically significant difference was observed between the length of the molars (p2) and the length between the infradentale and the coronion (p3) in females ($p<0.05$). However, no such difference was found in our study.

In a study conducted on mice (Enomoto et al. 2010), the mandibular measurements by CT were reported as 10.62 ± 0.29 mm for mandibular length, 9.86 ± 0.09 mm for corpus length, and 4.85 ± 0.11 mm for ramus height after 1 week of being fed pelleted food. After 4 weeks, these values increased to 11.02 ± 0.81 mm for mandibular length, 10.44 ± 0.14 mm for corpus length, and 5.34 ± 0.04 mm for ramus height. In our study, the CT measurements for female New Zealand rabbits were 64.519 ± 1.405 mm for mandibular length, 10.126 ± 0.481 mm for corpus length, and 38.510 ± 1.305 mm for ramus height, while in males, these values were 65.573 ± 2.346 mm for mandibular length, 10.107 ± 0.546 mm for corpus length, and 37.545 ± 1.121 mm for ramus height. When compared to mice, the corpus mandibula length was found to be similar between the two species.

Borie et al. (2017) conducted a morphometric study on rabbit mandibles using digital callipers to evaluate their use in implant and oral surgery, and found that the longest mandible length was 67.2 ± 2.0 mm. In New Zealand rabbits (Selçuk 2024), these values were 61.468 ± 0.978 mm for males and 62.553 ± 1.146 mm for females. In our study, the values were 65.573 ± 2.346 mm in males and 64.519 ± 1.405 mm in females.

In studies on the 3D reconstruction of extremity bones in New Zealand rabbits using a 3D scanner and computed tomography (Koçyiğit 2023; Koçyiğit and Demircioğlu 2024), Bland-Altman analysis was applied to evaluate the method compatibility. It was found that all parameters were within the limits of agreement, and the methods could be an alternative for morphometric measurements. Similarly, in our study, all data were determined to be within the limits of agreement when Bland-Altman analysis was performed.

In a study conducted on Hamdani sheep (Güzel et al. 2022), digital calipers, photometric analysis, and 3D software were used to measure metacarpal bones, and it was observed that some parameters showed similar results with no statistically significant differences, while others showed significant statistical differences. However, in our study, all parameters were found to be similar, and no statistically significant differences were detected.

In conclusion, the mandibular measurements of male and female New Zealand rabbits obtained through 3D scanning and CT were compared, and similar results were found for both methods. It is thought that this result will be a

resource for researchers working on experimental mandibular surgery in rabbits and that taking measurements with a 3D scanner has more advantages than the CT device in terms of morphometric measurement, higher detail, colour scan and surface scanning. The CT device is advantageous because it scans the entire tissue and gives very fast results. As a result, it is thought that using both methods together will be advantageous for researchers.

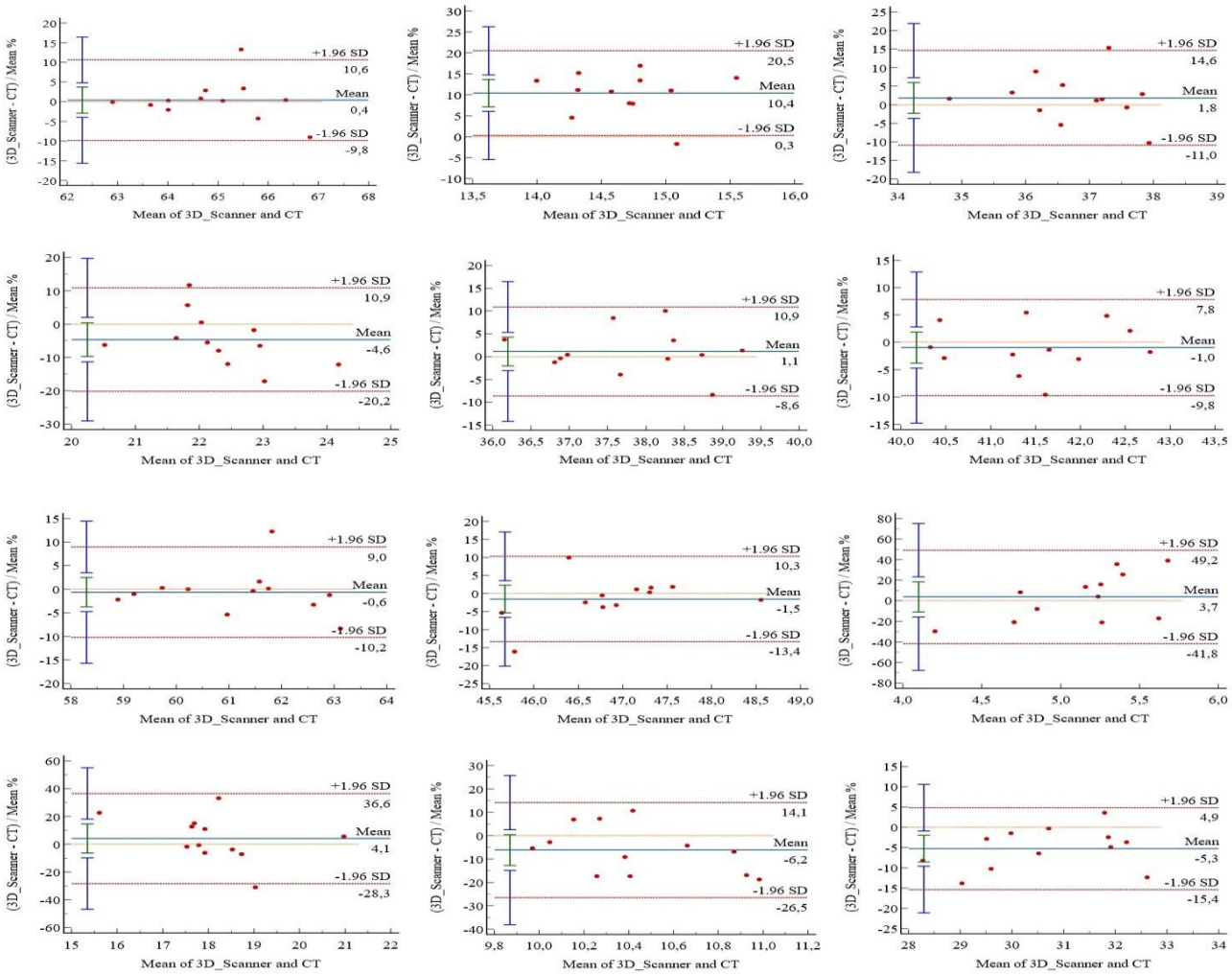

Figure 2: Bland-Altman analysis of method compatibility.

CONFLICTS OF INTEREST

The authors report no conflicts of interest.

AUTHOR CONTRIBUTIONS

Idea / Concept: AK, FAK
Supervision / Consultancy: İD, BK
Data Collection and / or Processing: AK, FAK
Analysis and / or Interpretation: AK, İD, BK
Writing the Article: BK, İD
Critical Review: AK, İD, FAK

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