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**MORPHOLOGICAL, RADIOLOGICAL AND
MORPHOMETRICAL STUDIES ON THE TEETH
IN RABBIT**

(With 4 Tables & 7 Figures)

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دراسات مورفولوجية واشعاعية وقياسية على الأسنان في الأرنب

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يشمل هذا البحث على دراسات مورفولوجية واشعاعية وقياسية على أسنان كلا الفكين في الأرنب . لوحظ أن الأسنان الشدقية العلوية تكون مجاورة لبعضها بينما تبتعد أسنان الفك السفلي عن بعضها من أسفل ، أظهرت الدراسة من الوجهة الاكلينيكية أن القبطاحن الأول والثاني يبرزان في الجيب الفك العلوي أما القبطاحن الثالث والطواحن يبرزون في الحديبة الوتدية الحنكية وبالتالي يبرزون في الجزء الأمامي البطني للتجويف الحجاجي . السطح الاطباقي للأسنان الشدقية غير مستوي ومائل ولذلك لوحظ أن الحافة الشدقية لأسنان الفك العلوي والحافة اللسانية لأسنان الفك السفلي حادة وبارزة . جميع الأسنان الشدقية محدبة بطولها ولكن درجة واتجاه التحذب يختلف في الأسنان المختلفة . أوضحت الدراسة أيضا أن جميع أسنان الأرنب لها ثقب قمي واسع . السطح الاطباقي للقواطع العلوية الأمامية له ميزاب مستعرض حيث تستريح الحافة الحادة للقواطع السفلية . تاج القواطع والأسنان الشدقية السفلية أكثر ظهورا من الخارج عنه من الداخل عكس ما وجد في الأسنان الشدقية العلوية . تبين أيضا أن القاطع العلوي الأمامي أطول أسنان الأرنب . وبصفة عامة فإن الأسنان الشدقية العلوية أطول من الأسنان الشدقية السفلية . القبطاحن العلوي الثالث أطول الأسنان الشدقية والطواحن السفلي الثالث أقصرهم . أوضحت النتائج أن سمك الأسنان الشدقية أكبر من عرضها ولهذا نجد هذه الأسنان مبططة من الأمام الى الخلف . أظهرت الدراسة أن الأسنان في الأرانب قريبة الصلة بالقوارض من ناحية ولكن لها صفات اكلاات الأعشاب من ناحية أخرى .

SUMMARY

The present work includes morphological, radiological and morphometrical studies on the teeth of both jaws in rabbit. The upper cheek teeth are closely related to each other, while the lower ones are diverged distally. From the clinical point of view, P₁ and P₂ project in the maxillary sinus, but P₃ and molars invaginate within the sphenopalatine tuber inturn within the rostroventral portion of the orbital cavity. The occlusal surface of the cheek teeth is uneven and oblique. Therefore the buccal edge of the upper and the lingual edge of the lower cheek teeth are sharp and prominent. In general the cheek teeth are convex along their length, but the degree and direction of convexity vary in the different teeth. All the teeth of the rabbit have wide apical foramen. The occlusal surface of the rostral upper incisors has transverse groove where rests the sharp edge of the lower ones. The crowns of the incisors and lower cheek teeth are exposed more externally than internally contrast to that found in the upper cheek teeth. The rostral upper incisor is the longest tooth in rabbit. In general the upper cheek teeth are longer than lower ones. The upper P₃ is the longest and the lower M₃ is the shortest tooth among all the upper and lower cheek teeth. Except in lower P₁ the thickness of cheek teeth is higher than breadth, consequently these teeth are flattened rostrocaudally. The rabbit appears to be closely related to the rodents dentition in one hand, but it has also the characteristic herbivores dentition in the other hand.

Key words: Teeth in rabbit

INTRODUCTION

During recent years the rabbits are considered to be one of the important sources of meat in egypt, in addition they are one of the common experimental animals. In spite of this, the anatomy of the rabbit especially that of the teeth received a little attention of investigators. However, the teeth in different species of the adult domestic animals had been the subject for several investigators (El-Hagri, 1967; Nickel, Schummer and Seiferle, 1973; Clair, 1975 and Dyce, Sack and Wensing, 1987). Therefore, the aim of this work is to give more informations about the morphology, radiology and morphometry of the teeth in rabbit.

MATERIAL and METHODS

Fourteen heads of adult bala di rabbit of both sexes were used in the present work. The skulls were cleaned from the soft tissues. The lateromedial radiographs of the upper and lower jaws were made. Some morphological features were described on the teeth within the bone, then they were removed from their alveoli to complete these features and the other investigations. Using Precision Digital Verner Caliper the different dimensions of the teeth were measured.

RESULTS

The inner wall of the alveoli of the upper incisors extends more distally than the outer wall, on contrast in case of the cheek teeth the outer wall extends more distally than the inner wall. Consequently the outline of the inlet of the alveoli is obliquely located and slopes dorsolaterally from the lingual edge in the incisors, but slopes ventrolaterally in the cheek teeth. As a result the crowns of the upper incisors are exposed more externally than internally, while those of the cheek teeth are exposed more internally than externally. In the lower jaw the inner wall of the alveoli extends more proximally than the outer wall. Consequently the inlet of the alveoli slopes ventrolaterally from the lingual edge, in turn the crowns of the lower teeth are exposed more externally than internally. The diastema (Figs. 1, 2, 3) is generally wide and measures 28.92 mm in the upper jaw and 21.16 mm in the lower jaw. It is clear that the diastema of the upper jaw is longer than that of the lower jaw and the ratio between them is 4 : 3. Moreover it forms more than the half length of the upper jaw and less than the half length of the lower jaw.

The upper incisors (Figs. 1, 2) are arranged into two rows; rostral and caudal. Each contains a pair of teeth. The labial surface of the rostral incisors is strongly convex along its length as well as from side to side. It has a distinct median longitudinal groove extends along the whole length. The lingual surface is concave and grooved. The contact surfaces are smooth and flat. The occlusal surface is quadrilateral in outline, it slopes dorsocaudally from the labial edge. Therefore this edge is sharp and projects more distally. The labial edge is also notched due to extension of the longitudinal groove. The occlusal surface contains a transverse

groove where rests the sharp edge of the opposite surface of the lower incisors. The root of the rostral incisor occupies nearly the rostral half of the diastema.

The caudal upper incisors are smaller and less curved than the rostral ones. Moreover, their surfaces are smooth and do not contain grooves. Each tooth lies opposite to the level of the median longitudinal groove of the labial surface of the corresponding rostral incisor. Its root is relatively short and occupies the rostral fifth of the diastema. The apical ends of all incisors are occupied by wide apical foramens.

The lower incisors are two in number, they directed rostrally and somewhat dorsally. Each incisor is curved (Fig. 3). The labial surface is convex along its length, while the lingual surface is concave. The both surfaces and the contact surfaces are smooth and flat from side to side. The occlusal surface is sharp and high rostrally, it slopes ventrocaudally toward the lingual edge. The root of the lower incisor is long and occupies the whole body of the mandible. Therefore, it extends along the diastema to terminate at the level of the mental foramen just rostral to P₁ (Fig. 3).

The incisors except the caudal upper ones are longer than the cheek teeth (Tables 1, 2). The rostral upper incisor (22.11 mm) is longer than the lower incisor, and is considered also the longest tooth of the rabbit. The crowns of the rostral upper and that of the lower incisors have nearly equal length (Tables 1, 2), but these teeth differ in the length of their roots. The caudal upper incisors are shorter and narrower than the rostral ones. The thickness (Tables 3, 4) at the neck region of the rostral upper and lower incisors has the highest value. However, the thickness has pronounced low value at the crown of these teeth, because their occlusal surfaces are oblique. In case of caudal incisors the thickness is nearly equal along its length and ranged from 1.15 to 1.19 mm. In general the breadth of all incisors is higher than the thickness. This explains that these teeth are flattened from rostral to caudal.

The upper cheek teeth (Figs. 1, 4) are six in number, 3 premolars and 3 molars. They occupy small area (about one third) of the upper jaw. The distance between the first and last cheek teeth at the crown region (15.66 mm) is nearly equal to that at the root region (15.15 mm). As a result the upper cheek teeth (Fig. 2) are closely related at the crown and also at root region. The upper P₁ lies about 0.65 mm rostral to the temporal process of zygomatic bone. This tooth and P₂ project within the

caudoventral portion of the maxillary sinus. The apical end of the latter tooth terminates directly distal to the infraorbital canal, while that of P₃ ends ventrocaudal to the maxillary foramen. The previous tooth and the molars invaginate proximally within the sphenopalatine tuber. Therefore, they occupy the rostroventral portion of the orbital cavity (Fig. 2). From the clinical point of view, the apical ends of these teeth form a pumpy edges within the orbit and they are covered by thin bones.

The lower cheek teeth (Figs. 3, 5) are five in number, 2 premolars and 3 molars. They lie between the mental foramen rostrally and the mandibular foramen caudally. They are sagittally located, however the ramus of the mandible are directed caudolaterally. Therefore, their alveoli extend more laterally in the mandible and the wall of the alveoli becomes thicker medially than laterally. P₂ is vertical in position (Fig. 3) and P₁ is directed ventrally and somewhat caudally while the molars are ventrocaudally directed, the degree of caudal inclination increases caudalwards. The distance between the first and last cheek teeth (Fig. 3) at the crown (15.40 mm) is shorter than at the root region (20.83 mm). Consequently the lower cheek teeth are closely related proximally and diverged distally.

In general the cheek teeth are convex along their length but the degree and direction of convexity vary in the different teeth. Except P₁ the convexity faces medially in the upper cheek teeth, but faces rostrally in the lower ones. The convexity of upper P₁ faces rostrally. In general the degree of convexity increases caudalwards.

The buccal and lingual surfaces of the upper P₁ and M₃ are smooth. While in the other upper cheek teeth the former surface is concave and the latter is convex, each has a longitudinal groove (Fig. 4) extends along the whole tooth length. The groove of the lingual surface is deeper than that of the buccal one. The mesial contact surface of P₁ is convex and has two longitudinal grooves, but the opposite surface is smooth and concave. The contact surfaces of other upper cheek teeth are smooth.

The buccal surface of the lower P₁ has two longitudinal grooves separate three columns (Fig. 5), the middle one is thicker than the others. In the other cheek teeth except M₃ this surface has one groove which lies somewhat caudally and separates two unequal columns. The rostral column is larger than the caudal one. The buccal surface of M₃ is smooth. The lingual surface of P₂ contains faint median longitudinal groove. This groove is deeper and situates more caudally in the other lower cheek

teeth. The contact surfaces of the lower cheek teeth are smooth, except the mesial contact surface of P₁ contains a median longitudinal groove. In the lower cheek teeth the mesial contact surface is convex, but the opposite surface is concave, the curvature is less pronounced in P₂.

The occlusal surface of the cheek teeth is uneven and oblique, it slopes dorsomedially in the upper jaw and ventrolaterally in the lower jaw. Therefore, the buccal edge of the upper teeth (Fig. 4) and the lingual edge of the lower teeth (Fig. 5) are sharp and prominent. The occlusal surface of the upper cheek teeth except P₁ has a large transverse ridge separating two small grooves. P₁ contains median transverse groove instead of the ridge.

The occlusal surface of the lower cheek teeth except P₁ and M₃ has transverse groove separates two parts, the rostral part is (Fig. 5) higher and larger than the caudal one. This surface is notched in both sides. In case of P₁ the occlusal surface contains transverse ridge separating two grooves, moreover this surface has two notches (Fig. 5) on its buccal aspect. The occlusal surface of M₃ has faint transverse groove. The apical ends of the cheek teeth are quadrilateral in outline, they are occupied by wide apical foramens.

The total length of the upper cheek teeth (Table 1) is ranged from 9.21 to 17.93 mm. The highest length is recorded in P₃ (Fig. 6), then it decrease rostral to reach 12.82 mm at P₁. The length decreases also from P₃ caudad toward M₃ to reach 9.21 mm. The upper premolars (mean length 15.74 mm) are longer than the molars (mean length 13.90mm).

The total length of the lower cheek teeth is ranged from 8.85 mm to 14.58 mm. The highest value (Fig. 7) is observed in M₁, then the length decreases in rostral direction to reach 13.42 mm at P₁. From M₁ the length decreases also caudalwards to reach 8.85 mm at M₃. The lower premolar (mean 13.48 mm) are also longer than the molars (mean 12.28mm).

In general the upper cheek teeth (mean length 14.82 mm) are longer than the lower cheek teeth (mean length 12.76 mm). The upper P₃ is considered the longest tooth (17.93 mm), however the lower M₃ is the shortest tooth (8.85 mm) among all the upper and lower cheek teeth.

The crown of the cheek teeth is shorter than the corresponding root. But the ratio between the length of both differs in the different teeth as shown in the Tables (1, 2). The lowest ratio (1 : 1.90) is recorded in the upper P₁, while the highest ratio (1 : 4.19) in the upper M₂. Except in

the lower P₁, the thickness of the cheek teeth is higher than the breadth (Tables 3, 4). This indicates that these teeth are flattened rostrocaudally. While in case of the lower P₁ the breadth is higher than the thickness.

Table 1: Showing some dimensions (mm) of teeth of upper jaw.

Tooth	Total length	Crown length	Root length	Ratio between crown / root
I (rostral)	22.11	7.79	14.32	1 : 1.84
I (caudal)	10.71	3.33	7.38	1 : 2.22
P1	12.82	4.42	8.40	1 : 1.90
P2	16.46	3.93	12.53	1 : 3.19
P3	17.93	4.48	13.45	1 : 3.00
M1	16.88	3.48	13.40	1 : 3.85
M2	15.62	3.01	12.61	1 : 4.19
M3	9.21	2.75	6.46	1 : 2.35

Table 2: Showing some dimensions (mm) of teeth of lower jaw.

Tooth	Total length	Crown length	Root length	Ratio between crown / root
I	20.69	7.42	13.27	1 : 1.79
P1	13.42	4.46	8.96	1 : 2.01
P2	13.54	3.42	10.12	1 : 2.96
M1	14.58	3.10	11.48	1 : 3.70
M2	13.40	2.81	10.59	1 : 3.77
M3	8.85	1.87	6.98	1 : 3.73

Table 3: Showing thickness and breadth (mm) of teeth of upper jaw.

Tooth	Thickness at			Breadth at		
	Crown	Neck	Root	Crown	Neck	Root
I (rostral)	1.57	2.40	1.98	2.91	2.85	2.66
I (caudal)	1.15	1.19	1.16	1.68	1.55	1.54
P1	3.33	3.33	3.19	1.99	1.97	1.83
P2	4.48	4.49	4.30	2.46	2.46	2.23
P3	4.38	4.55	4.27	2.47	2.67	2.43
M1	4.30	4.40	4.21	2.52	2.55	2.17
M2	4.11	4.22	3.90	2.43	2.45	2.18
M3	1.70	1.76	1.68	1.36	1.36	1.34

Table 4: Showing thickness and breadth (mm) of teeth of lower jaw.

Tooth	Thickness at			Breadth at		
	Crown	Neck	Root	Crown	Neck	Root
I	1.89	2.14	2.11	2.70	2.80	2.75
P1	2.59	2.85	2.84	3.17	3.22	3.16
P2	3.17	3.20	3.10	2.62	2.60	2.66
M1	3.18	3.35	3.04	2.69	2.85	2.65
M2	3.11	3.16	3.10	2.57	2.62	2.63
M3	1.92	1.95	1.96	1.70	1.83	1.75

DISCUSSION

The present work shows that in rabbit the rostral upper incisors reach nearly to one half of diastema. Similar result was recorded in chinchilla by Wiggs and Lobprise (1997). They added that the upper incisors reach to one half to two thirds in hamsters, two thirds in rat, three quarters in mice, one third in lagomorph (including rabbit) and extend to the level of the first cheek tooth in guinea pig. In agreement with Thakur and Puranik (1984) the lower incisors extend caudally in the lower jaw to terminate just in front the first premolar. The same results was nearly obtained by Wiggs and Lobprise (1997). They added that the lower incisors reach to first or second premolar in chinchilla, second cheek tooth in guinea pig and reach to last molar in rat and hamsters.

The tips of the lower incisors in rat can be brought into a position either before or behind the tips of the upper incisors (Pfeifer, 1954). In rabbit the lower incisors bite between the rostral and caudal upper incisors (Thakur and Puranik, 1984). However, the present study indicates that the sharp labial edge of the lower incisors rests on the transverse groove of the occlusal surface of the rostral upper incisors.

The present finding reveals that the occlusal surface of the rostral upper and lower incisors is oblique and has sharp labial edge. This feature was not observed in the caudal lower incisors. Hillyer and Quesenberry (1997) recorded that in rabbit and rodent the enamel is deposited on the front surface of the incisors only. The back surface is composed of dentin, and because enamel is harder than dentin, the front surface wears down more slowly. Therefore, the incisors remain in a permanently sharp condition from gnawing. Fielding and Matheron (1993) reported the same

result. Manning, Ringler and Newcomer (1994) explained that if the teeth do not wear properly in rabbit, as occur in malocclusion, the incisors continue to grow and may appear as tusks.

Corresponding to the present study and the statement of Tahkur and Puranik (1984), fielding and Matheron (1993), Okerman, Moens and Sundahl (1994) and Wiggs and Lobprise (1997) the total number of the teeth in the rabbit is 28. While Manning *et al.* (1994) observed a possible variation in the number of the upper molars (either two or three), therefore the total number becomes 26 or 28. This may be due to the fact that the last set of molars is exceptionally small and potentially difficult to visualize (Wiggs and Lobprise, 1997). The present work confirms this opinion morphometrically and explains that the last molar is the shortest upper cheek tooth.

The present work shows that the lower cheek teeth lie about 21.16 mm caudal to the incisors, between the mental and mandibular foramina. Thakur and Puranik (1984) mentioned that in rabbit the cheek teeth are placed little away from the incisors. But Hebel and Stromberg (1976) stated that the mandibular foramen in rat lies away from the cheek teeth, it situates midway along a line between the condyloid process and the third molar. It was observed in the examined rabbits that the lower cheek teeth are sagittally located, however the ramus of the mandible is directed caudolaterally. Therefore, the alveoli of these teeth extend more laterally in the mandible and the wall of the alveoli is thicker medially than laterally.

It was found that in the investigated rabbits P_1 and P_2 project within the caudoventral portion of the maxillary sinus. While P_3 and molars invaginate within the sphenopalatine tuber, they form a thin bumpy edges in the rostroventral portion of the orbital cavity. This explains that diseases of these teeth similar to impacted wisdom teeth may effect on the structures of the rabbit orbit. From the clinical point of view, Richardson and Mrcvs (1997) indicated that in rodents the earliest symptoms of malocclusion are lacrimal discharges as the upper teeth roots grow towards orbit.

The present study reveals that the cheek teeth in rabbit are generally convex along whole length, but the degree and direction of the convexity vary in the different teeth. Except P_1 the convexity of the upper cheek teeth faces medially, while that of the lower cheek teeth is directed rostrally. The convexity faces rostrally in the upper P_1 . The degree of

convexity increases caudalwards. On the other hand, Thakur and Puranik (1984) pointed out that the premolars and molars in rabbit are very much alike in external appearance, the only point of difference between them is that the molars do not have predecessors in milk dentition. However, the current work shows that the premolars of the upper and lower jaws are longer than the corresponding molars.

Corresponding to Hebel and Stromberg (1976) the size of the molars in rat decreases from M1 to M3. In this respect, the present work indicates that in rabbit the P3 is the longest upper cheek tooth (17.93 mm), then the length decreases rostralwards to reach 12.82 mm at the P1. The length also decreases from the P3 toward M3 to reach 9.21 mm. On contrast, M1 is considered the longest lower cheek tooth (14.58 mm). From her the length decreases in a rostral and caudal direction to reach 13.42 mm at P1 and 8.85 mm at M3 respectively.

The morphometrical study indicates that the upper cheek teeth (mean 14.82 mm) are longer than the lower cheek teeth (mean 12.76 mm). The upper P3 is the longest tooth (17.93 mm) and the lower M3 is the shortest tooth (8.85 mm) among all the upper and lower cheek teeth. In this respect Thakur and Puranik (1984) reported that the first premolars of the upper jaw are smaller than the others. The present work shows also that the crown of the cheek teeth is shorter than the corresponding root, but the ratio between the length of both differs in the different teeth. In general the lowest ratio was observed in upper P1 and the highest ratio in the upper M2.

According to Eaton (1960) in rodents as well as Hebel and Stromberg (1976) in rat the cheek teeth and the incisors are separated by a wide interdental space, the diastema. Similar result was given in the recent study but the length of the diastema of the upper jaw is longer than that of the lower jaw inturn the ratio between them is nearly 4 : 3 respectively.

Clair (1975) stated that after the tooth has erupted there is no further increase in the size except that the root adds a small amount of substance which closes its pulp cavity, except a foramen for the vessels and nerves. However, in open rooted teeth, substance is added continually. The incisors of rodents have open roots. Richardson and Mrcvs (1997) reported that the teeth in rodents grow continually through life. Wells (1968) as well as Hebel and Stromberg (1976) recorded that the apical foramen in rat remains opens throughout life, thus continuous

growth of the tooth is possible. the present work indicates that in rabbit the apical ends of the incisors and cheek teeth are occupied by wide apical foramens, consequently these teeth can grow continually. This result was confirmed by Wiggs and Lobprise (1997) in the cheek teeth as well as Thakur and Puranik (1984) in the incisors. The latter authors mentioned that the incisors are permanently open and hence this teeth grow throughout life. They are, however, kept to their normal size as their edges wear away when the upper and lower incisors bite against each other.

The absence of the more lateral incisors and canines as well as the presence of large diastema are the common traits of rodents (Eaton, 1960 and Wiggs and Lobprise, 1997). Corresponding to the present findings the rabbit has the same characters, but it contains two rows of upper incisors compared with one row in rodent, moreover they differ in the general arrangement of cheek teeth. The general features of the cheek teeth in examined rabbits concerning with the number and the occlusal surface is characteristic herbivores dentition which were described in domestic animals (El-Hagri, 1967; Nickel *et al.*, 1973; Bone, 1979; Ibrahim, 1983; Dyce *et al.*, 1987 and Abdalla, 1990). In this respect, Wiggs and Lobprise (1997) reported that in rabbit the lateral grinding movement is facilitated in the caudal teeth with the flat occlusal surface and deep transverse enamel. Also, Bone (1979) confirmed this statement in the herbivores and stated that the molars and premolars with their flat surface, complexly folded components and rough occlusal surfaces are excellent grinders. From all the aforementioned statements it is concluded that the rabbit appears to be closely related to the rodents dentition in one hand, but it has also the characteristic herbivores dentition in the other hand.

LEGENDS

- Fig. 1:** Photograph of the sagittal section of the skull showing the rostral and caudal incisors (1), and upper cheek teeth (2). From right to left P1, P2, P3, M1, M2 and M3.
- Fig. 2:** Mediolateral radiograph of the sagittal section of the skull showing rostral and caudal incisors (1), and upper cheek teeth (2).

- Fig. 3:** Mediolateral radiograph of the hemimandible showing lower incisors (1), and cheek teeth (2). Notice the distal divergence of cheek teeth. From left to right P1, P2, M1, M2 and M3.
- Fig. 4:** Photograph showing the lingual and occlusal surfaces of the upper cheek teeth. From right to left P1 (1), P2 (2), P3 (3), M1 (4), M2 (5) and M3 (6). Notice the buccal edge of the occlusal surface is prominent.
- Fig. 5:** Photograph showing the buccal and occlusal surfaces of the lower cheek teeth. From left to right P1 (1), P2 (2), M1 (3), M2 (4) and M3 (5). Notice the lingual edge of the occlusal surface is prominent.
- Fig. 6:** Histogram showing the total, crown and root length (mm) of the teeth of the upper jaw.
- Fig. 7:** Histogram showing the total, crown and root length (mm) of the teeth of the lower jaw.

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