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# Skull Typology and Morphometrics of the Nigerian Local Dog (*Canis lupus familiaris*)

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Summary: Understanding skull anatomy and morphometry is crucial to the diagnosis and treatment of some osteology disorders. This study investigated the morphometry and skull typology of the skull of the Nigerian local dog as a skull prototype for the dolichocephalic breed of dogs. A total of sixteen adult dogs (7 males, 9 females), of about 2 years were used. A total of 20 parameters were measured on each skull, and two indices (cephalic and orbital) calculated. The males had higher values for nine parameters (two of which were calculated indices), including the maximum width of the skull, length of the mandibular symphysis, height of the tympanic bulla and height of the external auditory opening, although no statistically significant difference was observed ($p > 0.05$). Statistically significant difference was observed in only one parameter, the length of the parietal bone ($p = 0.0505$), with the female value ($3.775 \pm 0.388$ cm) being higher than the male ($3.4 \pm 0.179$ cm). Cephalic and orbital indices ($52.69 \pm 4.677$ % and $80.87 \pm 7.218$ % respectively) were higher in males ($54.13 \pm 1.616$ % and $81.57 \pm 4.295$ % respectively) than in females ($51.24 \pm 6.434$ % and $80.35 \pm 9.102$ % respectively), although no statistically significant difference was observed ($p = 0.6905$ and $0.9483$ respectively). Results obtained from this study will provide baseline data on dolichocephalic skull measurements and also find application in archaeology, veterinary forensic medicine and applied anatomy.

**Keywords:** Nigerian local dog, skull, osteology, morphometry, sexual dimorphism



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## INTRODUCTION

Dogs have been reported to be the earliest domesticated species (Napierala and Uerpmann, 2012) and thousands of years of selective breeding by humans have led to enormous morphological diversity among dogs (Benecke, 1994). Due to the epochs-long efforts in systematic selection for different purposes and much creative experimentation, most of this morphological variation can now be recognized as breeds in contemporary dogs (Onar *et al*., 2012).

From time immemorial, dogs have been reputed to be man's best friend, with different breeds being attributed with different gifts and usefulness. Reports on the morphometric evaluation of the skulls of the archaeological remains of the Stone Age dogs and of modern day dogs have also increased in recent times (Onar, 1999; Baranowski, 2010; Igado, 2011; Onar *et al*., 2012; Igado and Ekeolu, 2014).

The shape of the skull in dogs shows considerable breed and individual variation in form and size (Getty, 1975). The shape of the skull is the most important criterion in determining the

standard breeds of dog (Onar, 1999). This might be one of the reasons, or the major reason why the canine skull of different breeds, both archaeological excavations, and modern day/ contemporary dogs has been studied by different authors.

The Nigerian local dogs (NLD) are a breed indigenous to Nigeria; they are popularly referred to as 'mongrels' by indigenes. They are characteristically long-headed (dolichocephalic) dogs (Igado, 2011), and are generally light brown in colour. Recent years has shown an increase in the acquisition of this breed of dog, due to the fact that they are more resistant to some haemo-parasites (e.g. babesiosis and trypanosomosis) that constantly plague the imported or exotic breeds (Olayemi *et al*., 2009). In rural areas in Nigeria, they are traditionally used for hunting.

This study aims to morpho-metrically evaluate the skull of the Nigerian local dog (NLD) relative to other dolichocephalic and non-dolichocephalic breeds, while also highlighting the gender differences in the skull typology. Results obtained may be useful in the field of maxillofacial and cranial surgery or other clinical manipulations involving the head, and serve as a possible template for dolichocephalic dogs.

## MATERIALS AND METHODS

Ethical approval for this study was obtained from the Ethical Committee of the Faculty of Veterinary Medicine, University of Ibadan, Nigeria, Ethical code number 'ethic/05/11/01'. All procedures followed the Guide for the care and use of experimental animals (National Institute of Health (NIH), USA and the Faculty of Veterinary Medicine, University of Ibadan, Nigeria).

Sixteen clinically healthy adult NLD (7 males, 9 females) were used for this study and obtained from a rural community in Ibadan city, Oyo State, Nigeria, where there was no likelihood of breeding with other breeds of dogs, whether dolichocephalic, mesaticephalic or bradycephalic.

All animals were aged 2 years or more and their ages were confirmed by using the dental formula according to Dyce *et al*., (2002). The animals were euthanized by intravenous injection of pentobarbitone and the heads were severed at the atlanto-occipital junction. The severed heads were skinned and de-fleshed with a scalpel blade as much as possible, and thereafter subjected to the hot water maceration technique as previously described by Igado (2011).

A total of 20 parameters were measured on each skull and the linear measurements determined with the aid of digital vernier callipers, centimetre rule and mathematical dividers. The parameters measured and their landmarks are described below and illustrated in Figures 1-4. All measurements were recorded in centimetres (cm), while all specimens were photographed with a digital camera (Sony® Cyber-shot digital still camera – DSC-HX400/HX400V).

1. Whole skull height (WSH): measured as the distance between the highest level of the frontal bone and the lowest level of the mandible.
2. Whole skull length (WSL): this is the total length of the skull measured as the distance from the most rostral aspect of the dental pad to the most caudal aspect of the occipital bone.
3. Skull height without the mandible (SHWM 1): height of the skull from the highest limit of the frontal bone to the most ventral limit of the sphenoid bone just below the foramen magnum.
4. Skull height without the mandible (SHWM 2): from the level of the highest point of the frontal bone to the base/lowest level of the jugular process.
5. Maximum width of the skull (MWS): breadth/width of the skull, measured from zygion to zygion (zygomatic bone to zygomatic bone).
6. Total length of frontal bone (FBL): this was measured from the rostral tip of the bone, where it articulates with the maxilla and nasal bones, to the caudal border where it forms a suture with the parietal bone.
7. Overall length of the nasal bone (NBL): from the rostral end of the frontal bone to the rostral tip of the nasal bone.
8. Length of parietal bone (FNE): length from the fronto-parietal suture to the nuchal eminence.
9. Length of the mandibular bone (MDL): Length of the mandible, measured as the distance from the most rostral point of the dental bone to the caudal limit of the mandibular condyle.
10. Mandibular symphysial length (MSL): length of the mandibular symphysis, measured from its rostral to the caudal limit.
11. Length of palate (PAL): measured along the midline, from the most rostral aspect of the incisive bone, to the most rostral aspect of the choanae.
12. Length of the perpendicular plate of the palatine (UMP): measured from the most rostral aspect of the choanae to the suture between/joining the perpendicular plate of the palatine bone and the pterygoid.
13. Tympanic bulla length (TBL): measured from the rostral aspect to the caudal aspect of the bulla.
14. Width of the tympanic bulla (TBW): measured as the distance from one lateral side to the other lateral side.
15. Greatest height of the tympanic bulla (TBH): measured from the most dorsal aspect to the most ventral aspect, excluding the height of the external auditory opening.
16. Height of the external auditory opening (EAPH): measured vertically, in a straight line, as the distance between the dorsal and ventral limits of the openings. Measurements were taken consistently from the left side.
17. Width of the external auditory opening (EAPW): measured horizontally, in a straight line, as the distance between the two lateral limits of the openings. Measurements were taken consistently from the left side.
18. Orbital height/vertical diameter (OVD): height of the orbit, measured from the ventral aspect of the orbital rim (at the zygomatic arch) in a vertical line to the dorsal aspect of the rim. Measurements were taken consistently from the left side.
19. Orbital width/horizontal diameter: this was measured along two different planes. Distance from the point of the zygomatic arch, directed rostrally at 90$^o$ to the rim of the orbit (OHD1). Secondly, distance from the point of the zygomatic arch, directed rostrally in a straight line to the rim of the orbit at the lacrimal fossa (OHD). Measurements were taken consistently from the left side.
20. Orbital index: $\left(\frac{orbital\ width-OHD}{orbital\ height-OVD}\right)\ x\ 100$
21. Cephalic index: $\left(\frac{skull\ width-MWS}{skull\ length-WSL}\right)\ x\ 100$

**Statistical Analysis**

The data collected were analyzed using SPSS v.24 and expressed as mean±SD. The student t-test and ANOVA were used for the comparison of the means and a p-value $< 0.05$ was accepted as statistically significant.

**RESULTS**

Results are presented in Figures 1 – 5 and Tables 1 and 2.

The examined skulls were sixteen in number, and comprised of seven males (43.75%) and nine females (56.25%). Nine parameters were observed to be higher in the males, although no statistically significant differences were observed (P>0.05). Only one value, length of the parietal bone (FNE) showed statistically significant difference (P<0.05), with the female being higher than the male (Table 1). Correlation of WSH and WSL with other measured parameters, using Pearson's correlation showed the highest values between WSH and WSL, WSH and SHWM 2, WSH and TBW, and WSL and SHWM 2 (r = 0.9244, 0.6658, 0.567 and 0.5461 respectively) (Table 2).

The presence and prominence of the external sagittal crest varied in both genders. Four of the male skulls (57.14%) examined showed a prominent external sagittal crest extending to the caudal border of the dorsal aspect of the skull, while the remaining 3 (42.86%) showed a flattened area or absence of the crest. In the females, of the 9 skulls examined, 6 (66.67%), showed a prominent crest, 1 skull (11.11%) possessed a less prominent crest, while 2 skulls showed an absence of the crest (22.22%). In the animals possessing the crest, the females appeared to have a slightly more pronounced crest relative to the males (Figure 5). The mandibles were not completely fused.

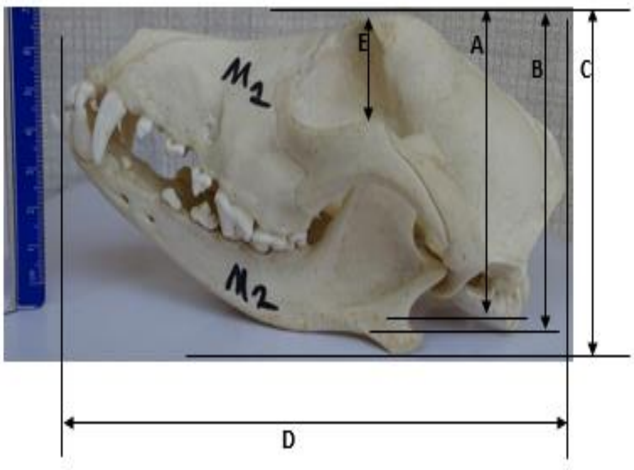


**Figure 1:** Lateral view of the male NLD skull, showing the skull height without mandible - SHWM 1 (A), the skull height without mandible - SHWM 2 (B), the whole skull height (C), whole skull length (D), height of the orbit – OVD (E).

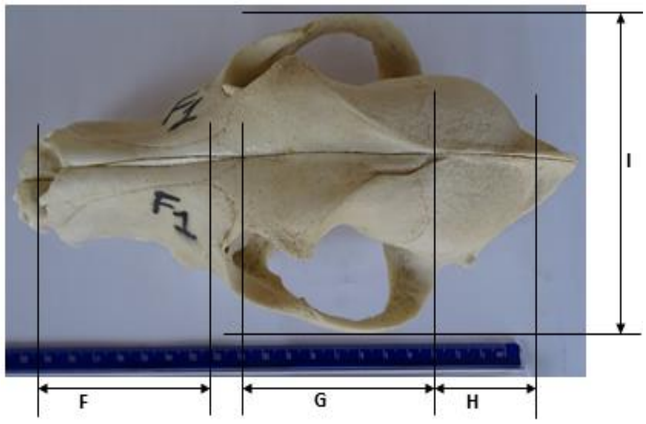


**Figure 2:** Dorsal view of the female NLD skull, showing the length of the nasal bone – NBL (F), length of the frontal bone – FBL (G), length of the parietal bone – FNE (H) and the width of the skull – MWS (I).

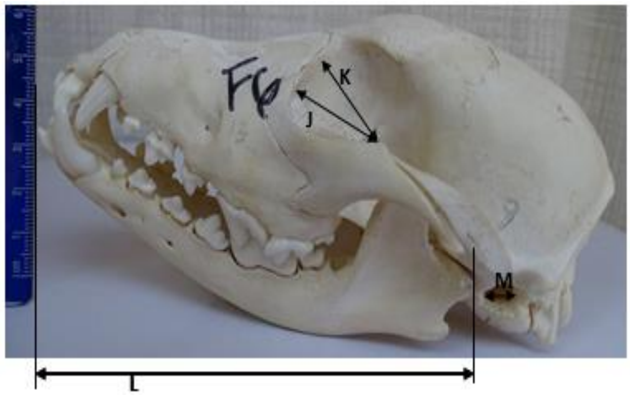


**Figure 3:** Lateral view of the female NLD skull, showing the widths of the orbit, OHD (J) and OHD1 (K), length of the mandibular bone – MDL (L), width of the external auditory opening – EAPW (M)

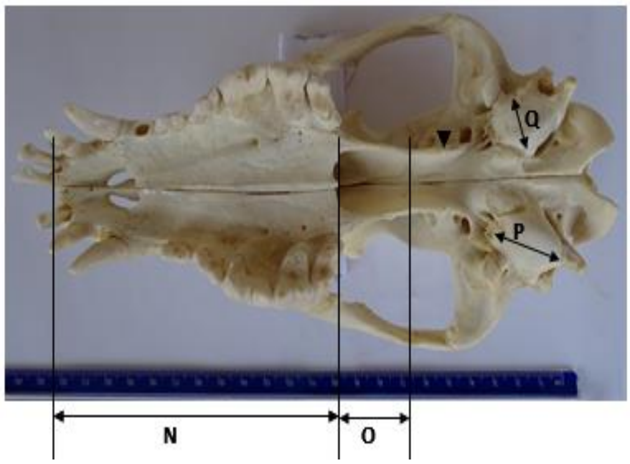


**Figure 4:** Ventral view of the female NLD skull, showing the length of the palate – PAL (N), the length of the perpendicular plate of the palatine bone – UMP (O), length of the tympanic bulla – TBL (P) and width of the tympanic bulla – TBW (Q). Arrow head indicates the hamulus of the pterygoid bone

**Table 1:** Skull measurements of the Nigerian local dog (*Canis lupus familiaris*) (Mean ± Standard deviation)

| **Parameters (cm)** | **Total n = 16** | **Male, n = 7** | **Female, n = 9** |
|---|---|---|---|
| WSH | 8.15 ± 0.665 | 8.02 ± 0.581 | 8.280 ± 0.786 |
| WSL | 16.22 ± 1.393 | 15.8 ± 1.1 | 16.64 ± 1.647 |
| SHWM 1 | 4.508 ± 0.616 | 4.125 ± 0.591 | 4.70 ± 0.566 |
| SHWM 2 | 4.707 ± 0.646 | 4.483 ± 0.574 | 4.875 ± 0.682 |
| MWS | 8.493 ± 0.734 | 8.517 ± 0.674# | 8.475 ± 0.823 |
| FBL | 5.607 ± 0.484 | 5.5 ± 0.369 | 5.688 ± 0.567 |
| NBL | 6.16 ± 0.622 | 5.95 ± 0.656 | 6.3 ± 0.616 |
| FNE | 3.614 ± 0.361 | 3.4 ± 0.179* | 3.775 ± 0.388* |
| MDL | 11.46 ± 1.246 | 11.05 ± 0.787 | 11.76 ± 1.481 |
| MSL | 1.9 ± 0.301 | 1.933 ± 0.197# | 1.875 ± 0.373 |
| PAL | 7.842 ± 0.849 | 7.6 ± 0.534 | 8.014 ± 1.024 |
| UMP | 1.527 ± 0.241 | 1.48 ± 0.192 | 1.567 ± 0.288 |
| TBL | 1.914 ± 0.175 | 1.833 ± 0.151 | 1.975 ± 0.175 |
| TBW | 1.307 ± 0.144 | 1.3 ± 0.167 | 1.313 ± 0.136 |
| TBH | 0.9714 ± 0.173 | 1.017 ± 0.172# | 0.9375 ± 0.177 |
| EAPH | 0.55 ± 0.109 | 0.5833 ± 0.133# | 0.525 ± 0.08864 |
| EAPW | 0.6 ± 0.104 | 0.6167 ± 0.117# | 0.5875 ± 0.099 |
| OVD | 2.843 ± 0.179 | 2.833 ± 0.197 | 2.85 ± 0.177 |
| OHD 1 | 2.493 ± 0.182 | 2.55 ± 0.105# | 2.45 ± 0.220 |
| OHD | 2.3 ± 0.260 | 2.317 ± 0.271# | 2.288 ± 0.270 |
| Orbital index (%) | 80.87 ± 7.218 | 81.57 ± 4.295# | 80.35 ± 9.102 |
| Cephalic index (%) | 52.69 ± 4.677 | 54.13 ± 1.616# | 51.24 ± 6.434 |

* Shows statistically significant difference between male and female parameters ($P<0.05$). # Indicates values which are higher in the males, although no statistically significant differences were observed ($P>0.05$).

**Table 2:** Pearson's correlation coefficient values WSH and WSL against other skull morphometry parameters in the Nigerian local dog.

| | **WSH** | **WSL** | **SHWM 1** | **SHWM 2** | **MWS** | **FBL** | **NBL** | **FNE** | **MDL** | **MSL** |
|---|---|---|---|---|---|---|---|---|---|---|
| **WSH** | - | 0.9244 | 0.3948 | 0.6658 | 0.4255 | 0.1676 | 0.2689 | 0.3055 | 0.3133 | 0.1502 |
| **WSL** | 0.9244 | - | 0.1747 | 0.5461 | 0.3384 | 0.2521 | 0.2263 | 0.4141 | 0.2804 | 0.1528 |

| | **PAL** | **UMP** | **TBL** | **TBW** | **TBH** | **EAPH** | **EAPW** | **OVD** | **OHD 1** | **OHD** |
|---|---|---|---|---|---|---|---|---|---|---|
| **WSH** | 0.1905 | -0.1272 | 0.2376 | 0.567 | 0.0818 | -0.128 | -0.044 | 0.0858 | 0.5328 | 0.1397 |
| **WSL** | 0.1557 | 0.0307 | 0.1006 | 0.436 | 0.0052 | -0.0734 | -0.0639 | 0.2169 | 0.4086 | 0.0541 |

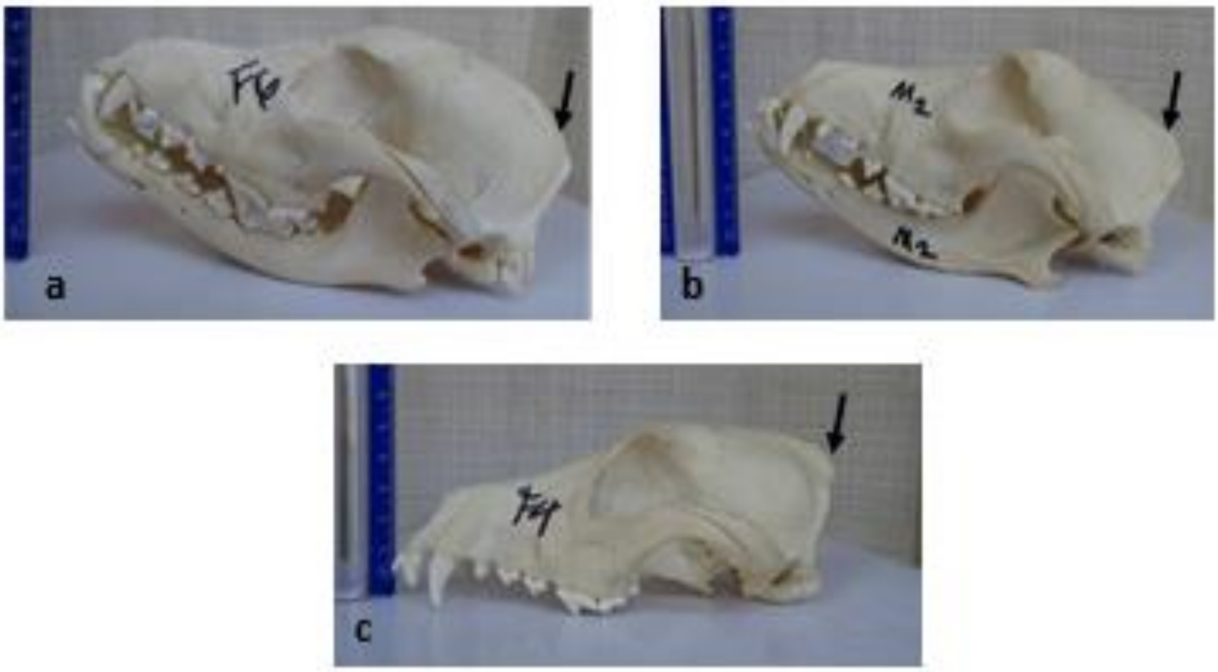


Figure 5: Lateral view of the male and female NLD skulls, note the differences in the appearance of the external sagittal crests. Panels (a) and (c) are female skulls, while panel (b) is a male skull.

## DISCUSSION

The morphological and morphometrical studies of the skull demonstrate the involvement of genetic and environmental components to individual development. It also describes the genetic and ecophenotypic variation, and can be said to be the foundation for surgical and clinical practices (Wehausen and Ramey, 2000). The shape of the skull observed in the NLD is consistent with previous reports in greyhound dogs and other hunting dogs (Schmidt *et al*., 2011; Onar *et al*., 2012). The cephalic index obtained is very similar to that obtained in the German shepherd by Onar (1999).

The external sagittal crest can be described as a ridge of bone which runs lengthwise, on the top of the skull, along the midline, observable in many mammalian and reptilian skulls and serves the function of muscle attachment. Its presence is taken to indicate the possession of exceptionally strong jaw muscles (Getty, 1975; Dyce *et al*., 2002). Traditionally, in Nigeria, both genders of the NLD are used for hunting and since in this study, the presence or absence of the crest could be not unequivocally linked to a particular gender, it might be difficult to ascertain which gender has the stronger jaw muscles. This lack of gender-bias for the sagittal crest in NLD is unlike the study in the Eurasian lynx where the males had the crest and the females did not (Gomerčić *et al.*, 2010). Due to the fact that these dogs are in some places kept semi-intensively and left to roam and mate freely, it is also possible that over the years, incidences of in-breeding might have resulted in the disparity in appearance of the crest. It is however worth mentioning that the strongest sagittal crest in this study was observed in a female, estimated to be about 5 to 6 years (the oldest estimated age in the group). This is at variance with the report of Gomerčić *et al.* (2010) on the absence of the sagittal crest in the female Eurasian lynx, in spite of the presence in the male of the species.

The appearance of the sagittal crest could also be age-related, as seen in the German Sherpherd (Onar, 1999). In a previous work on the skull of the Alsatian, as a dolichocephalic prototype, the appearance of the sagittal crests was observed in dogs of the age group 70 – 107 days, dogs of lower ages had a rounded skull where the sagittal crest was not yet visible. In the current study on NLD, skull specimens were from subjects aged at least 2 years. This disparity in appearance of the crest relative to age suggests that this feature might not necessarily be age related in all dog breeds possessing the sagittal crest, or the age at appearance varies greatly. It can also be inferred that development of the sagittal crest in this dog breed continues into adulthood (over 2 years). It is however possible that change in some skull features may occur over time due to inbreeding.

According to Slater and Basher (2007) and Koenig and Liebish (2007), in the dog, the dorsolateral wall of the orbit is formed by the dense collagenous orbital ligament between the zygomatic process of the frontal bone and the frontal process of the zygomatic bone. Also, in carnivores, the dorsal margin of the orbit is formed by the orbital ligament, which is often ossified in the cat. These reports are consistent with findings in this study, as seen by the non-closure of the dorsolateral aspect of the orbit.

Using the method of Garcia-Perea (1996) in lynxes to categorise the sagittal crest, the NLD could be categorised into 2 groups – sagittal crest present; and sagittal crest absent but ridge present. It should however, be noted that unlike the Garcia-Perea's report, dogs of two years and above were used for this study, as puppies could not be obtained at commencement of study.

Previous reports on the skull morphometry of the Alsatian, a dolichocephalic showed the skull length in ages 61 to 105 days old to be 14.388 cm (Onar, 1999), which is slightly smaller than the value $16.22 \pm 1.393$ cm obtained in this study, in spite of the vast difference in age. This similarity in skull length, despite the difference in age is due to the fact that the NLD are relatively smaller dogs compared to the Alsatians.

The males in this study had higher values for the height of the auditory opening. Correlating the size of the auditory opening with the pinna, this finding is at variance with reports by the same author where the females had higher values for the dimensions of the pinna (Igado, 2014).

In conclusion, this study presents information on the variation in skull typology of the dolichocephalic breed, useful for application in veterinary maxillofacial surgery and anaesthesiology, anthropological and archaeological studies.

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