Clinical Implications of Craniometric Indices of the One-Humped Camel (*Camelus dromedarius*) to Oral Health and Clinical Regional Anaesthesia of the Head.

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Abstract

A total of 30 indices were estimated in the mandible, maxilla and frontal bones of 30 adult and 12 young camels in Nigeria. The mandibular length was over 38cm while diastemal length was slightly over 6cm. The thickness of the mandibular body was significantly lower in the young camels compared to the adult. Various osteometric landmarks that will aid the tracking of mental, mandibular and supraorbital nerves were reported with no significant differences observed in most mandibular indices in adult camels between sexes and between camels in the different geographical locations studied. However, significant differences were found in all indices studied between young and adult camels. The craniometric information provided in this study will be important for camel handlers, camel clinicians and particularly for the regional anaesthesia of the head region.

Keywords:

Clinical Implication, Craniometry, Oral Health, *Camelus dromedarius*

Introduction

Craniometric studies of the skull of different animal species continue to be a growing area of applied research. The values obtained from such studies apart from being important in osteoarcheological fields (Parés *et. al*, 2010), determination of sexual dimorphism (Onar *et al*., 2001), basic anatomy (Saber, 1990; Olopade and Onwuka 2005a), evolution and adaptive studies (Evans and McGreery, 2006) can also be important in the fields of morphophysiology of mastication (Terai *et. al.*, 1998) and in regional anaesthesia of the head (Olopade and Onwuka, 2005b).

Studies on the craniometric indices of the one-humped camel are scarce in the literature (Al-Sagair and ElMougy, 2002); our observations from ongoing studies of the camel in Nigeria have revealed a profile of dental abnormalities (Yahaya *et al*., 2011). Thus, apart from giving information on interpretation of craniometric indices important for restrain and management of camel, it has become imperative to provide baseline data that will aid the tracking of nerves that will be important for regional anaesthesia, in particular dental extraction in camels**.**

Materials and Methods

A total of 30 adult camels, and 12 young camels (2-3 years of age) both with equal number of males and females were used for this study. The camel heads were obtained from abattoirs in three different cities (Maiduguri, Kano and Sokoto) in Northern Nigeria after slaughter and were aged based on the works of Wilson (1984). The skulls were then macerated according to methods of Onar *et al*. (2001) and Olopade and Onwuka (2009). Thirty craniometrical data and one descriptive landmark were obtained from the mandibles, maxillae and frontal bones of the skulls. The landmarks were described herein and shown in Figs 1-7.

One way analysis of variance (ANOVA) was employed to analyze the variations in measurement across three locations and means were separated using least significant difference test. Independent samples t-test was used to test the differences between adult and young camels indices.

The observed indices include:

Infraorbital foramen height (IFH): Minimum distance between the dorsal and ventral brim of the foramen (fig. 1).
Infraorbital foramen to dorsal alveoli root (IFAR): Distance from the lower brim of the infraorbital foramen directly to the dorsal root of alveoli (fig. 1).
Lateral alveoli root to cranial mental foramen (LAMF 1): Shortest distance from the dorsal rim of the rostral mental foramen to the extent of the alveolar root of the lower incisor (fig. 2).
Lateral alveoli root to caudal mental foramen (LAMF 2): Shortest distance from the dorsal rim of the caudal mental foramen to the alveolar root of the lower incisor (fig. 2)
Rostral mental foramen to mandibular caudal border (MFMB 1): Distance from the level of the rostral

mental foramen to the extreme caudal border of the mandible (fig. 2).

Caudal mental foramen to mandibular caudal border (MFMB 2): Distance from the level of the caudal mental foramen to the extreme caudal border of the mandible (fig. 2).

Condyloid fossa to base of the mandible (CFBM): Distance from the condyloid fossa to the base of mandible (fig. 2).

Fossa cranial to angular process to base of mandible (FABM): Distance from the deepest level of the fossa cranial to angular process to the mandibular base (fig. 2).

Mandibular length (MDL): Length of the lower jaw, from the top of the dental bone to the most caudal projection of the angle of the mandible (fig. 2).

Angular process to base of mandible (APBM): Distance from the maximum projection of the angular process to the base of mandible (fig. 3).

Mandibular body height at molar 1 (MDBH 1): Maximum height of the body of the mandible from the root of alveolar tooth to the mandibular base at molar 1 (fig. 3).

Mandibular body height at molar 2 (MDBH 2): Maximum height of the body of the mandible from the alveolar root to mandibular base at molar 2 (fig. 3).

Diastemal length in adult (DSLA): Length of the diastemal gap, from the caudoventral limit of premolar 1 to the cranioventral limit of the premolar 2 (fig. 3). In the young, it was from the caudoventral limit of the lateral incisor to the cranioventral limit of the premolar 2

Maximum mandibular height (MDH): Distance from the base of the mandible to the highest level of the coronoid process (fig. 3).

Mandibular foramen to the caudal border of mandible (MDFC): Length from the caudal most border of the mandible to the vertical line from mandibular foramen to the base of the mandible (fig. 3).

Maximum condyloid process height (CPH): Distance from the maximum height of the condyloid process to the base of the mandible (fig. 3).

Mandibular foramen to base of mandible (MDFB): Length of a vertical line from the ventral limit of the mandibular foramen to the base of the mandible (fig. 3).

Medial mandibular crest breadth (MDCC): Maximum breadth of the medial mandibular crest between the most medial points of the crest (fig. 4).

Mandibular (Symphyseal) length (MDSL): Length from the rostral to the caudal limits of the mandibular symphysis (fig. 4).

Diastemal breadth at cranial mental foramen (DSB 1): Maximum breadth of mandible on the bony line from the cranial limit of the cranial mental foramen (fig. 4).

Diastemal breadth at caudal mental foramen (DSB 2): Maximum breadth of mandible on the bony line at caudal end of the mandibular symphysis (fig. 4).

Condylar breadth 1(CB1): Breadth of the mandibles between the most medial points of the right and left condyles processes (fig. 5).

Condylar breadth 2(CB2): Breadth of the mandible between the most lateral end of the right and left condylar processes (fig. 5).

Inter-mandibular breadth 1 (IMDB 1): Maximum breadth between the two halves of the angle of the mandible (fig. 5).

Inter-mandibular breadth 2 (IMDB 2): Maximum breadth between the two halves of the medial end of the angular process (fig. 5).

Mandibular thickness at molar 1 (MDT 1): The maximum thickness of the mandible at the 1st molar (fig. 6).

Mandibular thickness at molar 2 (MDT 2): The maximum thickness of the mandible at the 2nd molar (fig. 6).

Mandibular thickness at molar 3 (MDT 3): The maximum thickness of the mandible at the 3rd molar (fig. 6).

Diastemal thickness at cranial mental foramen (DST 1): A complete circumference thickness of the mandible at the caudal end of the cranial mental foramen (fig. 6).

Diastemal thickness at mandibular symphysis (DST 2): A complete circumference thickness of the mandible at the caudal end of the mandibular symphysis (fig. 6).

Results

Craniometric data obtained from camel skulls in Nigeria is presented in Table 1-2; gender and age differences and effect of geographical location are highlighted.

Discussion

This work presents an indepth osteometric study of the mandible of the camel. The mandibular length of 39.15 ± 0.47cm, 38.41 ± 0.58cm and 38.38 ± 0.77cm in camels from Maiduguri, Kano and Sokoto, respectively, showed no significant difference. Also, the steady increase of mandibular thickness from molar 1 to molar 3 was uniform in the camels from all the three different locations studied depicting that vulnerability to injury like fracture could more easily occur in the mandible at the region of the first molar. This is particularly important because this region is more exposed to the exterior, especially during prehension, mastication of coarse food (Ghaji and Adegwa, 1986) and during manual handling. More importantly, our data on diastemal length in adult (DSLA), and the thickness of the entire mandibular body that increased at the level of caudal mental foramen (DST 2) when compared to that at the rostral end of the mandibular symphysis (DST 1) are all of clinical importance. This is because camels are usually restrained and pulled for movement by locals with strong ropes tied on the lower jaw at positions corresponding to the location of the diastema. The highly significant differences between adult and young camels in this study in the thickness of DST 1 and DST 2 respectively warrants that upmost care is taken in handling the latter at these positions.

Camels in Nigeria are predominantly found in the arid and semi-arid zones of the Northern part of the country. They are to a great extent neglected if the intensive management of feeding and their oral health is considered. While it appears that they can feed on coarse desert plants on which other animal species cannot survive (Ghaji and Adegwa, 1986), this could be at the expense of their dental integrity. Craniometric data that will aid regional anaesthesia of the head for surgical maneuvers in the mouth particularly dental extraction is thus pertinent.

The infraorbital foramen of the camel is relatively large (Smuts and Bezuidenhout, 1987) being over 2.5cm in height (IFH) in our study and this suggests that the infraorbital nerve may be easily accessible. The desensitization of this nerve may affect the alveoli of the upper incisors, canine, premolars and perhaps the initial molar teeth. In addition, our information of this foramen's distance to the dorsal alveolar root (IFAR) may further aid the tracking of the nerve. It is worthy of mention, however, that a range of 0.1-0.15cm difference may exist between adult camels.

The distances between the lateral alveolar roof and the rostral mental foramen (LAMF 1) and the corresponding distance for the caudal mental foramen (LAMF 2) are important landmarks. These will aid the tracking of the respective mental nerves of which desensitization can aid surgical work on the lips, lower incisors, canines and the alveoli of premolar teeth of the corresponding half (Hall *et. al*., 2000).

The blockage of the mandibular nerve with local anaesthetics using the landmarks from the caudal mandible (MDFB and MDFC) would in theory desensitize the entire dental arcades and surrounding structures (without skin, muscles and subcutaneous tissue) of the injected side (Hall, *et al*., 2000; Flechter, 2004).

There were no significant differences in all the mandibular indices of adult camels related to regional anaesthesia between the locations studied, and also between genders. This implies that for camels over 5 years, a uniform set of craniometric indices can be used to track related nerves. However, significant differences occur in immature camels (2-3 years old) in all parameters (mandibular and maxillofacial) studied when compared to adults and thus obvious that different craniometric dimensions have to be used in latter.

Regional anaesthesia involving the supraorbital (frontal) nerves will lead to 'deadening' of the region of the face lateral to the nerves including the upper eyelids (Hall *et al.*, 2000; Tay *et al*., 2006). In the camel, at least a pair of supraorbital foramina in the frontal depression is usually found at various distances from the midline. Infiltration of local anaesthetic agents at specific points using a moderate circumference created from the intersection of the dorsal midline with a line across the most dorsolateral edges of the orbit (Fig 7) can result in the desensitization of these nerves.

Camels are experiencing a resurgence of interest and their importance in the modern era may depend in great part to the complete understanding of their anatomy and physiology (Fowler, 1997). The sudden rise in the last decade of camel domestication for their meat, and milk, rich in minerals and vitamin C (Knoess, 1979; Konuspayeva *et al*., 2009), will demand more knowledge for effective management. The craniometric information provided in this study will be important for animal handlers, camel clinicians and particularly for the regional anaesthesia of the head.

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Table 1: Some Craniometric Indices of Skull of Young and Adult Camels in Nigeria

L	MD	MDM	MDF	SK	SKM	SKF	KN	KNM	KNF	YN**	YNM	YNF
IFH	2.7±016	2.68±0.32	2.74±0.14	2.58±0.23	2.78±0.35	2.38±0.30	2.63±0.20	2.48±0.26	2.78±0.31	2.37±0.05	2.30±0.09	2.43±0.06
IFAR	1.67±0.06[a]	1.60±0.05	1.74±0.10	1.51±0.05[b]	1.50±0.08	1.52±0.07	1.55±0.05[ab]	1.56±0.05	1.54±0.09	1.00±0.02	1.02±0.03	0.98±0.03
LAMF 1	1.61±0.10	1.70±0.14	1.52±0.14	1.60±0.13	1.78±0.21	1.42±0.14	1.61±0.12	1.68±0.24	1.54±0.04	1.44±0.07	1.57±0.10	1.32±0.09
LAMF 2	2.70±0.14	2.76±0.27	2.64±0.11	2.62±0.24	2.96±0.36	2.28±0.28	2.56±0.15	2.52±0.26	2.60±0.18	1.69±0.06	1.72±0.10	1.67±0.08
MFMB 1	30.18±0.28	30.64±0.38	29.72±0.32	29.63±0.47	30.66±0.58	28.60±0.38	29.54±0.39	30.12±0.50	28.96±0.53	23.49±0.27	23.57±0.35	23.42±0.46
MFMB 2	19.08±0.30	19.26±0.36	18.90±0.51	18.54±0.36	19.16±0.39	17.92±0.51	18.59±0.30	18.82±0.44	18.36±0.42	14.90±0.19	14.67±0.31	15.13±0.19
CFBM	14.19±0.25	14.74±0.22[o]	13.64±0.27	13.57±0.46	14.52±0.67	12.62±0.23	14.01±0.26	14.42±0.21	13.60±0.43	10.84±0.17	10.97±0.27	10.72±0.21
FABM	10.55±0.29	11.08±0.42	10.02±0.26	9.98±0.44	10.84±0.59	9.12±0.37	10.22±0.22	10.54±0.14	9.90±0.37	7.38±0.17	7.43±0.24	7.32±0.25
MDL	39.15±0.47	40.02±0.28	38.28±0.73	38.38±0.77	39.90±1.03	36.86±0.67	38.41±0.58	39.46±0.70	37.36±0.68	30.350.28	30.42±0.40	30.28±0.41
APBM	11.57±0.41	11.96±0.74	11.18±0.37	11.29±0.52	12.36±0.64	10.22±0.49	11.43±0.30	11.94±0.21	10.92±0.48	7.88±0.18	7.92±0.28	7.83±0.26
MDBH 1	4.82±0.18	5.10±0.22	4.54±0.24	4.70±0.35	5.4±0.29	4.00±0.48	4.81±0.19	5.12±0.29	4.50±0.19	2.98±0.11	3.07±0.09	2.9±0.21
MDBH 2	5.64±0.64	6.24±0.19	5.04±0.19	5.32±0.38	6.34±0.13	4.30±0.35	5.26±0.29	5.82±0.42	4.70±0.22	3.95±0.95	4.07±0.11	3.83±0.29
DSLA	6.22±0.20	6.38±0.34	6.03±0.20	6.29±0.92	6.46±0.22	6.12±0.06	6.29±0.16	6.24±0.18	6.37±0.38			
MDH	19.34±0.30	19.86±0.37	18.82±0.37	18.3±0.49	19.28±0.76	17.32±0.20	19.15±0.28	19.56±0.12	18.74±0.51	15.30±0.20	15.32±0.34	15.28±0.22
MDFC	4.65±0.10	4.88±0.12	4.42±0.09	4.38±0.18	4.78±0.20	3.98±0.16	4.56±0.12	4.64±0.19	4.48±0.17	3.51±0.05	3.43±0.08	3.58±0.04

All values are in cm

Table 2: Some Craniometric Indices of Skull of Young and Adult Camels in Nigeria

L	MD	MDM	MDF	SK	SKM	SKF	KN	KNM	KNF	YN**	YNM	YNF
CPH	15.71±0.31	16.38±0.26°	15.04±0.37	15.03±0.49	16.16±0.62	13.90±0.27	15.54±0.43	16.38±0.24	14.70±0.64	11.75±0.19	11.87±0.28	11.63±0.26
MDFB	6.77±0.16	6.92±0.31	6.62±0.11	6.51±0.27	7.02±0.3	6.00±0.22	7.00±0.17	7.32±0.18	6.68±0.22	5.48±0.16	5.80±0.25	5.17±0.06
MDCB	5.46±0.11	5.46±0.21	5.46±0.07	5.79±0.16	5.50±0.22	6.08±0.13	5.53±0.15	5.70±0.19	5.36±0.22	5.17±0.09	5.10±0.14	5.23±0.12
MDSL	12.52±0.30	13.08±0.37	11.96±0.33	12.29±0.40	13.26±0.44	11.32±0.21	12.38±0.32	12.86±0.47	11.90±0.35	8.02±0.09	7.98±0.12	8.05±0.15
CB 1	8.35±0.15	8.62±0.15	8.08±0.20	8.47±0.16	8.82±0.22	8.12±0.06	8.45±0.16	8.78±0.16	8.12±0.21	7.10±0.11	7.43±0.30	6.77±0.08
CB 2	16.41±0.23	16.90±0.29	15.92±0.21	16.12±0.34	16.88±0.46	15.36±0.15	16.37±0.31	17.04±0.37	15.70±029	13.02±0.14	13.20±0.11	12.83±0.24
IMDB 1	14.80.0.40	15.38±0.62	14.22±0.40	14.89±0.44	15.58±0.78	14.20±0.21	14.86±0.42	15.42±0.63	14.30±0.48	10.04±0.12	9.97±0.15	10.12±0.18
IMDB 2	12.13±0.32	12.84±0.33	11.42±0.31	11.18±0.34	11.08±0.70	11.28±0.15	11.59±0.50	11.96±0.91	11.22±0.48	8.88±0.07	9.00±0.05	8.77±0.11
MDT 1	2.87±0.04	2.82±0.07	2.92±0.02	2.73±0.11	3.00±0.11	2.46±0.09	2.92±0.08	3.02±0.11	2.82±0.10	2.08±0.06	2.18±0.09	1.97±0.03
MDT 2	3.53±0.08	3.46±0.12	3.60±0.13°°	3.35±0.12	3.58±0.17	3.12±0.10	3.40±0.10	3.62±0.12	3.18±0.10	2.75±0.06	2.85±0.11	2.65±0.06
MDT 3	3.82±0.07	3.76±0.13	3.88±0.04	3.64±0.10	3.90±0.09	3.38±0.09	3.79±0.08	3.84±0.13	3.74±0.09			
DSB 1	4.03±0.13	3.70±0.10	4.36±0.12	3.74±0.12	3.92±0.22	3.56±0.04	3.86±0.14	4.22±0.12	3.50±0.11	3.03±0.05	3.10±0.09	3.97±0.05
DSB 2	5.45±0.15	5.26±0.16	5.64±0.23	5.36±0.18	5.80±0.19	4.92±0.12	5.34±0.14	5.56±0.17	5.12±0.8	3.52±0.07	3.58±0.13	3.45±0.06
DST 1	12.05±0.30	11.46±0.25	12.64±0.40	11.46±0.39	12.26±0.54	10.66±0.27	11.72±0.32	12.38±0.36	11.06±0.35	10.62±0.16	10.65±0.30	10.58±0.14
DST 2	15.07±0.35	14.50±0.10	15.64±0.62	14.49±0.52	15.84±0.55	13.14±0.14	14.37±0.35	14.64±0.52	14.10±0.48	11.21±0.08	11.22±0.14	11.20±0.80

All values are in cm

Legend.
L: Landmark; MD: Maiduguri; MDM: Male Maiduguri; MDF: Female Maiduguri; SK: So-koto; SKM: Male Sokoto; SKF: Female Sokoto; KN: Kano; KNM: Male Kano; KNF: Female Kano; YN: Young; YNM: Young Male; YNF: Young Female. °Significant dif-ference between genders at $P<0.05$, °° Significant difference between genders at $P<0.01$
**Significant difference between young and adult camels in all parameters (all from Maiduguri) at $P<0.01$

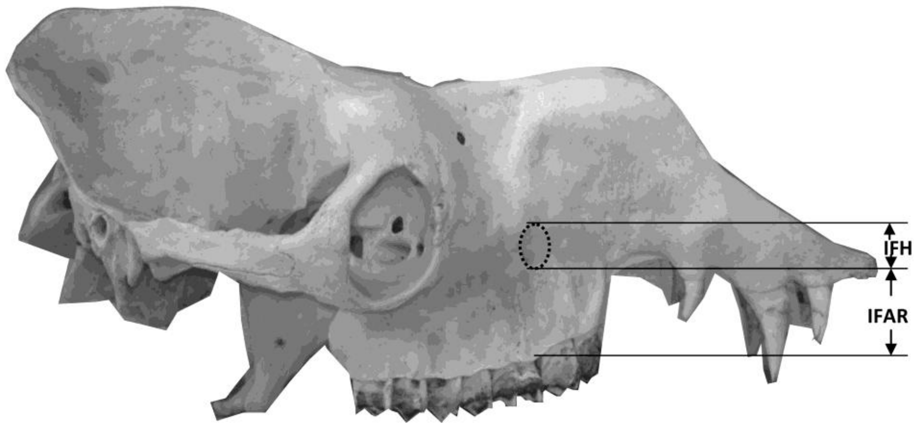

Fig (1): Measurement of the one- humped camel skull without the mandible (lateral view) showing infraorbital height (IFH) and infraorbital foramen to dorsal root of alveoli (IFAR). Mag. X125.

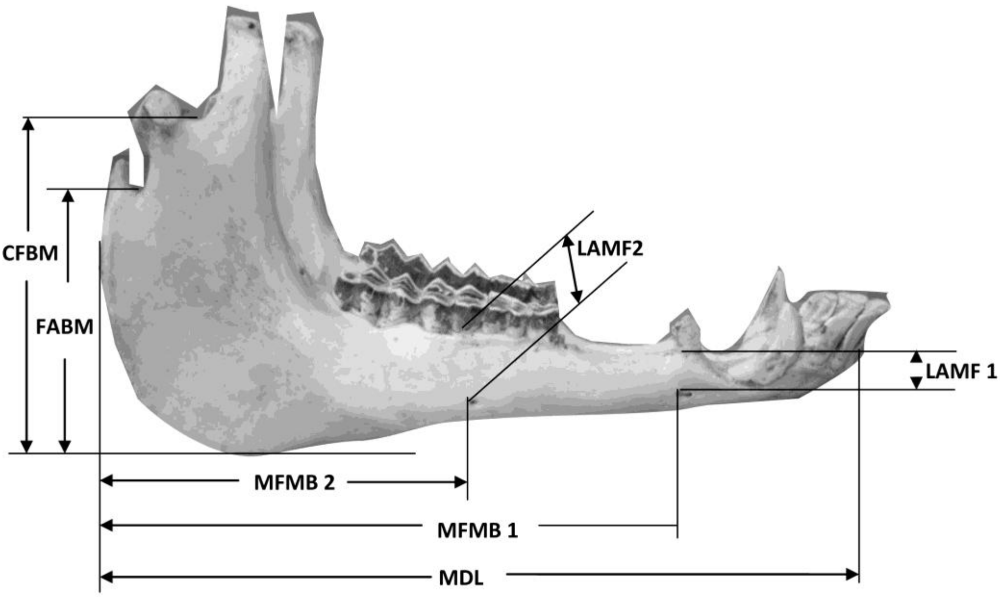

Fig (2): Measurements of the mandible of the one-humped camel (lateral view) showing lateral alveolar root to cranial mental foramen (LAMF1), lateral alveolar root to caudal mental foramen (LAMF2), cranial mental foramen to mandibular caudal border (MFMB1), caudal mental foramen to mandibular caudal border (MFMB2), condyloid fossa to base of the mandible (CFBM), fossa cranial to angular process to base of mandible (FABM) and mandibular length (MDL). Mag. X125.

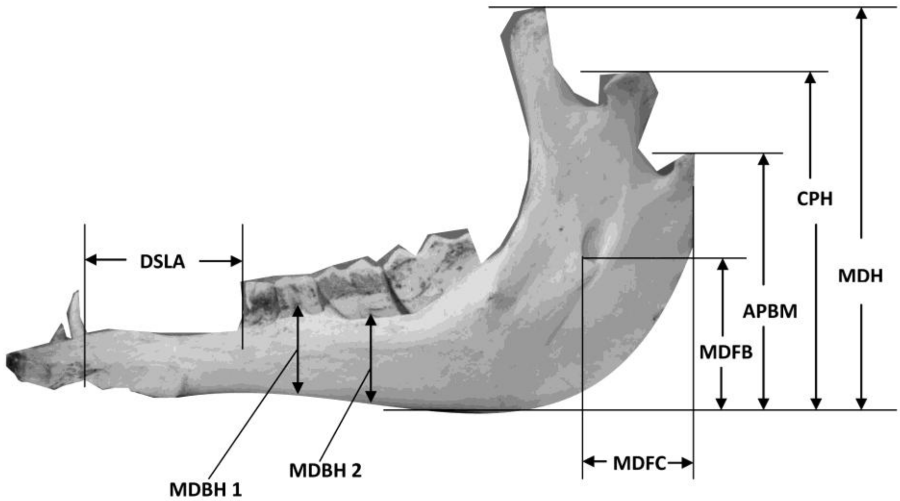

Fig (3): Measurements of the splitted mandible of the one-humped camel (medial view) showing mandibular foramen to base of mandible (MDFD), mandibular foramen to caudal border of mandible (MDFC), maximum mandibular height (MDH), maximum condyloid process height (CPH), angular process to base of mandible (APBM), mandibular body height at molar 1 (MDBH 1), amdnibular body height at molar 2 (MDBH 2) and diastemal length in adult (DSLA). Mag. X125.

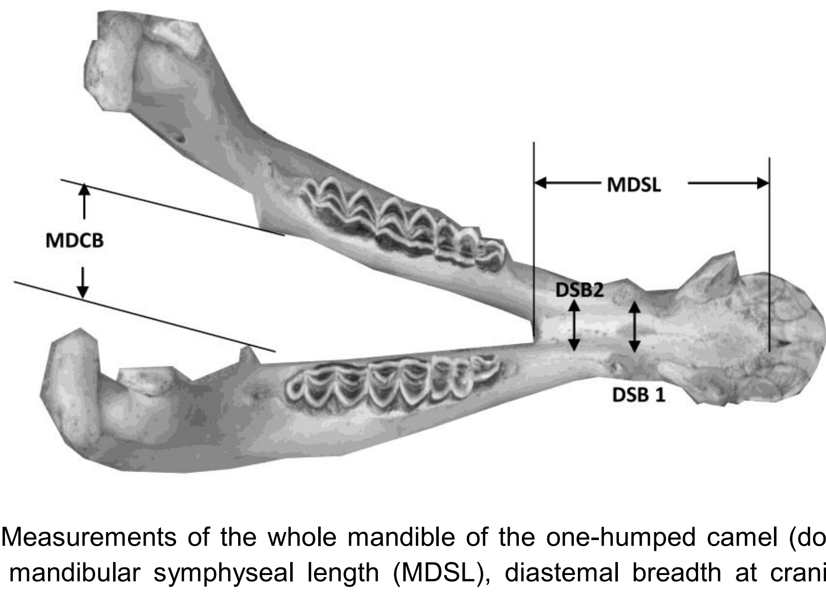

Fig (4): Measurements of the whole mandible of the one-humped camel (dorsal view) showing mandibular symphyseal length (MDSL), diastemal breadth at cranial mental foramen (DSB1), diastemal breadth at caudal mental foramen (DSB 2) and medial mandibular crest breadth (MDCB). Mag. X125.

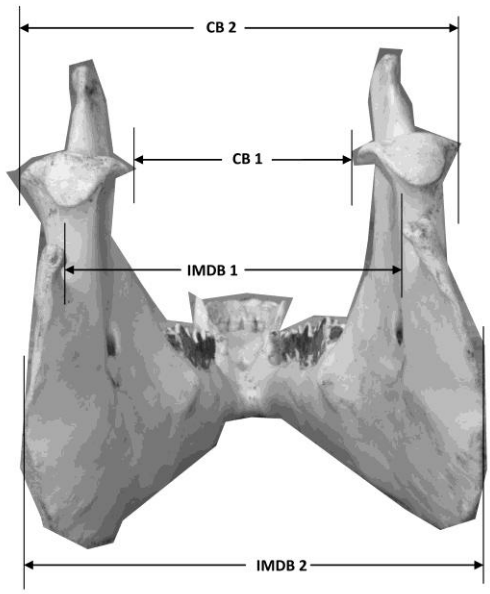

Fig (5): measurements of the whole mandible of the one-humped camel (caudal view) showing condylar breadth 1 (CB1), condylar breadth 2 (CB 2), inter-mandibular breadth 1 (IMDB 1) and inter-mandibular breadth 2 (IMDB 2). Mag. X125.

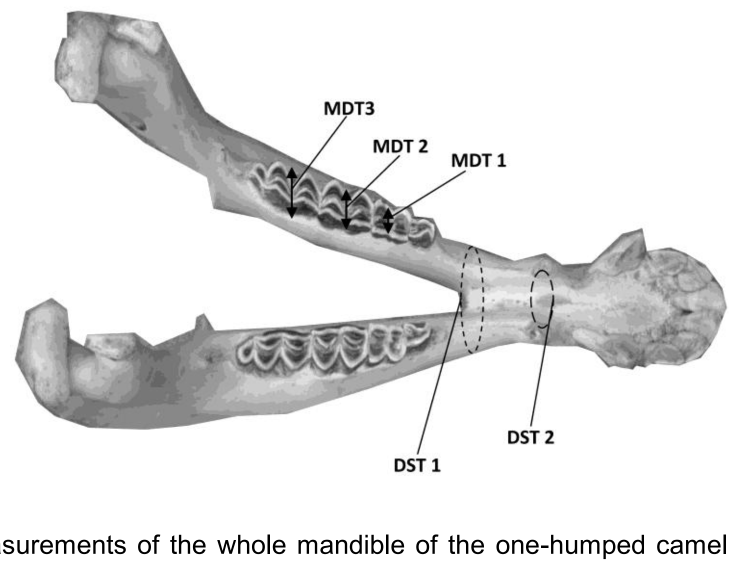

Fig (6): Measurements of the whole mandible of the one-humped camel (dorsal view) showing mandibular thickness at molar 1 (MDT 1), mandibular thickness at molar 2 (MDT 2), mandibular thickness at molar 3 (MDT 3), diastemal thickness at cranial mental foramen (DST 1) and diastemal thickness at mandibular symphysis (DST 2). Mag. X125.

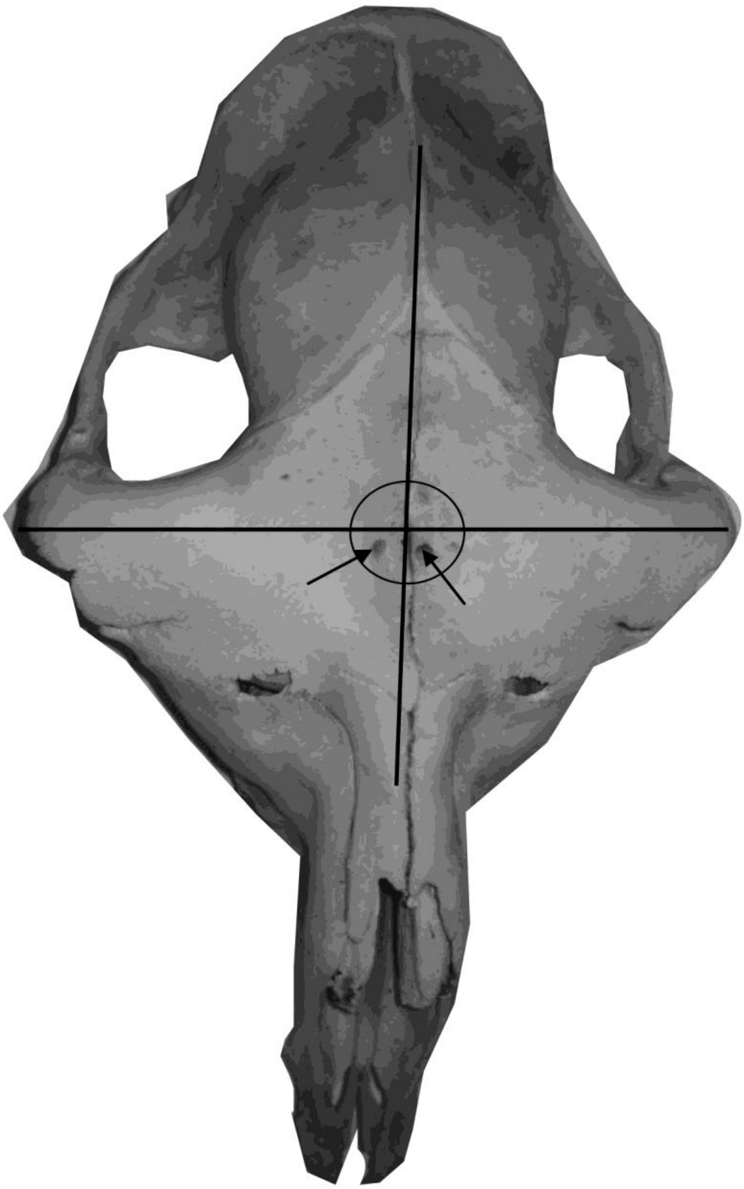

Fig (7): A proposed surgical landmark for the tracking of the supraorbital nerve in camels produced by a moderate circumference created from the intersection of a dorsal midline of the head with a line across the most lateral edges of the orbit, supraorbital foramen (arrows) Mag. X125.