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# Long-term results of remodelling the facial bones with a soft moulding helmet in beagles: the "reciprocally stimulated growth" hypothesis

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## Abstract

Facial deformity is often seen in infants with deformational plagiocephaly and it usually improves with conservative management. However, we know of few studies of the effect of helmet treatment on the facial skeleton. Our aim therefore was to find out its long-term effects on skull remodelling, and on the shape of the face. Seven beagles wore helmets for seven weeks after birth. Seven study beagles and 3 controls were killed and we measured the length, width, and height of the skulls, maxillas, and mandibles. Statistical analysis showed that the total craniofacial length and skull length did not differ significantly, and skull volumes were similar. Maximal craniofacial, skull, maxillary, and mandibular width were all significantly less in the study group. The maximal craniofacial, maxillary, and mandibular widths were strongly correlated with changes in the skull width, and the width:length ratios of the skulls, maxillas, and mandibles did differ significantly. The skull widths in the study group were significantly smaller, which suggests that a soft moulding helmet may change the growth pattern permanently. The effect of a soft moulding helmet on the lateral aspect of the skull affected the width of the face semipermanently. This modulation in the shape of the skull vault and base may change the shape of the maxilla and mandible, which may serve as a background for the use of helmet treatment to change the facial configuration.



*Keywords:* Plagiocephaly; Nonsynostotic; Orthotic Devices; Skull; Skull Base; Facial Bones; Dogs

## Introduction

Facial deformity or asymmetry is often seen in infants with cranial deformities because facial development is affected by the growth of the skull and the shape of the skull base.[1–3] Deformational plagiocephaly usually improves with conservative management, but if left uncorrected, severe deformational plagiocephaly may result in craniofacial asymmetry.[4,5] However, cranioplasty is rarely indicated for non-synostotic plagiocephaly, and helmet treatment is effective.[6,7]

According to the functional matrix hypothesis put forward by Moss, periosteal and capsular matrices are important components of craniofacial growth, and functional matrices affect the shape, size, and position of the craniofacial skeleton.[8] The application of a continuous external force to the growing skull can change its shape through the expansion of the neural mass, including the brain,[9,10] and induce changes in the skull base, which in turn can affect remodelling of the

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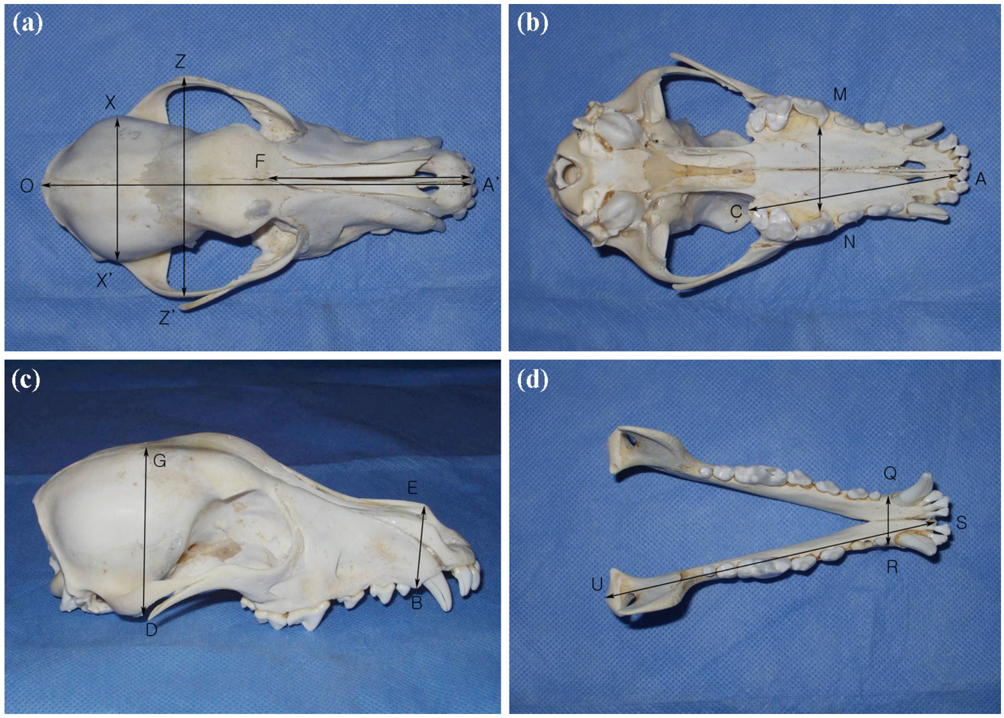


Fig. 1. Measurements using callipers-total craniofacial length (A'O): supradentale - occipital protuberance; skull length (FO)-nasion - occipital protuberance; maxillary length (AC)-posterior margin of alveolus of first incisor - posterior margin of last molar; mandibular length (SU)-infradentale - angular process of the mandible maximal craniofacial width (ZZ')-interzygomatic arch width, between the most posterior points of the suture of the zygomatic process of the temporal bone and zygomatic arch; skull width (XX')-between the most lateral parts of the skull, except for the zygomatic arch; maxillary width (MN): between the medial margins of the alveoli of the last premolars; mandibular width (QR)-between the mental foramina; skull height (DG): pterygoid hamulus – bregma; and maxillary height (BE)-posterior of canine - anterior medial margin of nasal bone.

facial bones.[11,12] We have considered the possibility that if the extent and direction of growth of the facial bones can be physically controlled with long-lasting results, the need for additional operations to correct an unattractive facial shape would be reduced.

Several studies have described the effect of helmet treatment for positional plagiocephaly, but we know of few studies of its effect on the facial skeleton. We have attempted to find out the long-term results of remodelling of the skull that can be achieved by helmet treatment, and its effects on the shape of the facial skeleton.

## Material and methods

Chung et al.[10] previously studied remodelling with a soft-helmet by evaluating cranial growth and volume changes for 8 weeks in 14 beagles, 7 of which acted as controls, to find out whether cranial remodelling with a soft moulding helmet is effective and safe. The beagles in the two groups remained healthy and grew well without any noticeable illnesses or neurodevelopmental problems. Seven of the study beagles and 3 controls were chosen randomly for this study. Beagles in the control group had not been given any other treatment since birth and developed well. Beagles in the experimental group wore helmets for seven weeks from the first week after birth (Fig. 1 Supplemental data).

We used helmets of different sizes that had been specifically designed for each developmental stage. The size was calculated by sequential measurements of the width and length of the skull in a beagle from the experimental group. These dimensions were modified so that the biparietal width of the helmet was the same as the mean width of the head, and the anteroposterior length was 30% longer than the mean length. All these processes resulted in restriction of growth of the bilateral parietal area of the head with no anteroposterior compression. When the anteroposterior length of a head grew to the same size as the helmet, the helmet was replaced with a new helmet of the next size.[10]

The dogs were killed when they were nine months old and skeletonised. The dimensions of the skulls and facial bones were measured using callipers, and the anatomical landmarks recorded (Fig. 1). The mean values of the results obtained by two independent researchers were used as the final values. Total craniofacial length (A'O), skull length (FO), maxillary length (AC), mandibular length (SU), maximal craniofacial width (ZZ'), skull width (XX'), maxillary width (MN), mandibular width (QR), skull height (DG), and maxillary height (BE) were measured (Table 1 Supplemental data). These measurements were compared with the corresponding measurements of the three dogs in the control group. The animals were treated according to the guidelines issued by the Committee on Research Animal Care and