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# The impact of dietary consistency on structural craniofacial components: Temporomandibular joint/condyle, condylar cartilage, alveolar bone and periodontal ligament. A systematic review and meta-analysis in experimental in vivo research

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ABSTRACT

*Objective:* The aim of this systematic review was to provide a comprehensive synthesis of available evidence evaluating the effect of dietary loading on temporomandibular joint/condyle, condylar cartilage, alveolar bone of the mandible and the periodontal ligament in healthy mice and rats.

*Design:* Medline via PubMed, EMBASE and Open Grey databases were searched for published and unpublished literature. Search terms included “mandiblular condyle”, “alveolar bone”, “temporomandibular joint”, “condylar cartilage”, “periodontal ligament”, “rat”, “mice”. After data extraction, risk of bias (SYRCLE) and reporting quality (ARRIVE) were assessed. Random effects meta-analyses were performed for the outcomes of interest where applicable.

*Results:* A total of 33 relevant articles were considered in the systematic review, while only 6 studies were included in the quantitative synthesis. Risk of Bias in all studies was judged to be unclear to high overall, while reporting quality was suboptimal. Comparing soft to hard diet animals, significantly reduced anteroposterior condylar length (4 studies, weighted mean difference: −0.40 mm; 95% CI: −0.47, −0.32; $p < 0.001$) and width (4 studies, weighted mean difference: −0.043 mm; 95% CI: −0.51, −0.36; $p < 0.001$) were found in rats. Decreased anteroposterior condylar dimensions were detected for mice as well (2 studies, weighted mean difference: −0.049; 95% CI: −0.56, −0.43; $p < 0.001$).

*Conclusions:* Overall, there was strong evidence to suggest a significant effect of soft diet on reduced condylar dimensions in rodents; however, there is need for further high quality experimental studies to inform current knowledge on condylar cartilage, alveolar bone and periodontal ligament related outcomes.

## 1. Introduction

During the course of human evolution, adaptations in human dental apparatus and craniofacial complex have taken place. Maxillary and mandibular bones have decreased in size, giving rise in tooth to alveolar bone discrepancies (Hanihara, Inoue, Ito, & Kamegai, 1981; Shiono, Ito, Inuzuka, & Hanihara, 1982) and increasing prevalence of malocclusions (Kelly & Harvey, 1977). According to anthropologic data, this is a relatively recent phenomenon whereas a much lower incidence of malocclusions has been reported for “primitive” populations (Beyron, 1964; Hunt, 1961; Liu, 1977; Lombardi & Bailit, 1972; Price, 1936; Wood, 1971). Notwithstanding, the form to function relationship of the jaws is genetically controlled and this has been demonstrated in inherited occlusal patterns pertaining within families (Kraus, Wise, & Frei, 1959; Lundström, 1948) or in whole ethnic groups (Björk, 1947; Cotton, Takano, & Wong, 1951; Craven, 1958); however not all phenotypic changes are due to the underlying genetic information. In early 1900s, the German anatomist and surgeon Wolff discovered that the internal architecture of femoral bone responds to external mechanical stress (Wolff, 2010). This constant adaptation of the trabecular bone can also be observed in the condylar process of the mandible and is ultimately based on variations in the level of activity of masticatory muscles.

In industrialized communities, life circumstances have changed dramatically with a subsequent impact on nutrition consistency. The dietary pattern has switched to “modern” processed diet which is softer and which goes along with a more limited use of the masticatory apparatus (Corruccini & Lee, 1984; Waugh, 1937). The masticatory

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system itself is a complex neuro-musculoskeletal system constituting from different parts, containing the horseshoe-shaped lower jaw body (corpus mandibulae) that supports the alveolar bone process which houses the teeth and their surrounding periodontal ligament. The lower jaw as a whole is connected with the masticatory muscles and the temporomandibular joint (TMJ) to the rest of the skull. The TMJ has always been the center of research interest as it consists of the condylar process and cartilage which is a highly adaptive and respondent to mechanical stress tissue (Eames & Schneider, 2008). As the force exerted on the TMJ is assumed to be greater during the mastication of hard food in contrast to softer diets (Boyd, Gibbs, Mahan, Richmond, & Laskin, 1990), a change in food consistency would inevitably pose an effect on the structures of the craniofacial system.

Due to ethical reasons, experimental evidence in human is very difficult to prove; however, a number of parameters have been examined in laboratory animal models. Rodents and in particular mice and rats have been used for this purpose since they are easy to handle, inexpensive to maintain and show a close genetic background to human, making them a convenient animal model for use. Animal studies in general have shown a direct causal relationship between reduced masticatory muscle function and modified dietary consistency. Soft diet has been linked with alterations in the muscle fiber composition, decreased fiber diameter, reduced total muscle weight and reduced masticatory muscle strength, which in turn has a subsequent effect on the craniofacial complex especially in growing animals (Beecher & Corruccini, 1981b; Kiliaridis & Shyu, 1988; Kiliaridis, Engström, & Thilander, 1988; Moore, 1965).

Although extensive animal studies have been published addressing the impact of dietary consistency upon both the hard and soft tissues, no systematic review has been performed in an attempt to place individual study conclusions into the appropriate context.

Therefore, the objective of this systematic review was to provide a comprehensive synthesis evaluating the effect of dietary loading on temporomandibular joint/condyle, condylar cartilage, alveolar bone of the mandible and the periodontal ligament in healthy mice or rats.

## 2. Material and methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Liberati et al., 2009; Moher, Liberati, Tetzlaff, & Altman, 2009) were followed for reporting of this systematic review.

### 2.1. Eligibility criteria

The following inclusion criteria were applied:

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  - Study design: Randomized or non-randomized experimental studies involving rodents were considered.
  - Population/ Animal: Any laboratory strain of rat or mice at any age.
  - Interventions: Soft diet administration for a given time period
  - Comparators: Hard/Normal diet administration for a similar time period.
  - Outcome measures: Effect of different type of dietary loading (i.e. soft/hard) on: 1. Temporomandibular joint/condylar process, 2. Condylar Cartilage, 3. Alveolar bone of the mandible and 4. Periodontal ligament.

Exclusion Criteria:

- In vitro studies
- Animal studies without a comparison group
- Animal studies involving diet switching (from hard to soft and/or vice versa)
- Not healthy animal populations (i.e., diabetic, ovariectomized etc)
- Animals being subject to other simultaneous interventions (i.e. incisor trimming, bite-blocks etc.)
- Studies pertaining to molecular, genetic, biochemical outcomes.

### 2.2. Search strategy

Electronic search within the following databases was undertaken in January 14, 2017, while no language restrictions were applied: Medline via Pubmed and EMBASE were searched. Moreover, unpublished literature was searched in Open Grey using the terms «diet» AND «rat OR mice». Hand searching of the reference lists of the retrieved full text articles was also conducted. Authors of original studies were contacted for data clarification if needed. Full search strategy implemented in Medline via Pubmed is presented in Appendix A.

### 2.3. Data extraction

Data extraction was performed on standardised piloted forms by one independently working reviewer (RS) and confirmed by a second (DK), both of whom were not blinded to author identity and study origin. Titles and abstracts were examined first, while at a second stage full text screening of the potential for inclusion articles was employed. Information was obtained from each included study on study design, population (type of animal), interventions, comparators and outcomes. In addition, information on duration of experiment and age of animals at the beginning of the active period of study was recorded. Any disagreements or ambiguity were resolved after consultation with a third author (TE).

### 2.4. Reporting quality

Reporting quality of the studies was assessed based on adherence to ARRIVE guidelines for reporting of animal studies (Kilkenny, Browne, Cuthill, Emerson, & Altman, 2010). According to completeness of reporting, the reporting quality was judged as “clearly inadequate”, “possibly inadequate” and “clearly adequate”. A grading system of 20 items contributed to the overall judgement of reporting quality (Table 1).

### 2.5. Risk of bias within studies

Risk of bias (RoB) in individual studies was assessed in line with the SYstematic Review Centre for Laboratory animal Experimentation

**Table 1**
Checklist of the 20 items corresponding to the ARRIVE guidelines.

| | Items |
|---|---|
| 1 | Title |
| 2 | Abstract |
| 3 | Background |
| 4 | Objectives |
| 5 | Ethical statement |
| 6 | Study design |
| 7 | Experimental procedures |
| 8 | Experimental animals |
| 9 | Housing and husbandry |
| 10 | Sample size |
| 11 | Allocating animals to experimental groups |
| 12 | Experimental outcomes |
| 13 | Statistical methods |
| 14 | Baseline data |
| 15 | Numbers analyzed |
| 16 | Outcomes and estimation |
| 17 | Adverse events |
| 18 | Interpretation/scientific implications |
| 19 | Generalizability/translation |
| 20 | Funding |