Craniofacial and Dental Effects Shown in Rats with Environmental Toxin (PCB-180) Exposure

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Background

Polychlorinated biphenyls (PCBs) are a large class of environmental toxins prevalent in our world today. Depending on their degree of chlorination and other properties, they can be highly persistent in our food, soil, water, and air[1]. Some PCBs are dioxin-like (DL) in their chemical structure, and thus have harmful toxic mechanisms similar to dioxins such as TCDD (Fig. 1)[2]. Although the vast majority of PCBs are non-dioxin-like (NDL), far less is known about their potential effects on human and animal health.

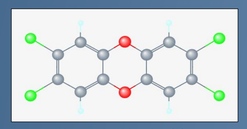

Figure 1: Dioxin-like compound (TCDD).

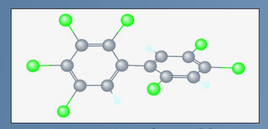

Figure 2: Non-dioxin-like compound (PCB 180).

In this study, we investigated the potential effects of NDL PCBs on the growth and development of the skull. We used the heptachlorinated congener PCB-180 as a model compound for NDL toxicity (Fig. 2) because this chemical is found in some of our favorite fatty foods[3] and has a half-life in humans of roughly ten years[4]. Using rats as a model organism for human development, we analyzed numerous variables of tooth and cranial development in male and female rats exposed *in utero* to different doses of PCB-180.

Photo credit: PubChem

Materials and Methods

Pregnant rats were exposed to six different dose treatments of PCB-180 (0, 10, 30, 100, 300, 1000 mg/kg body weight), and the crania of their offspring were analyzed at postnatal day 84 (Fig. 3). We measured 27 landmarks on 81 individual crania using a Microscribe G2X system (Fig. 4 and 5), in addition to measuring tooth diameter of each of the maxillary molars with digital sliding calipers. The landmark coordinates were analyzed with geometric morphometrics for variation in size, shape, and bilateral asymmetry using MorphoJ software. Comparisons of cranial and dental metric variables, as well as interfrontal bone frequency, were examined by dose group and sex.

Figure 3: Examples of rat crania used in study.

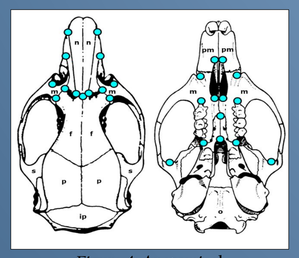

Figure 4: Anatomical landmarks measured in this study (blue circles) with labeled bones (n=nasal, m=maxilla, pm=premaxilla, f=frontal, s=squamosal, p=parietal, ip=interparietal, o=occipital).

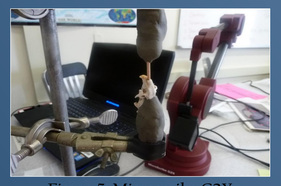

Figure 5: Microscribe G2X system.

Results and Analysis

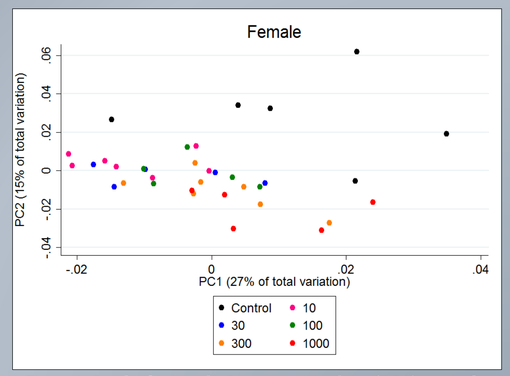

Figure 6: Graph of Principle Component Analysis (PCA) scores for craniofacial shape in females color coded by dose group.

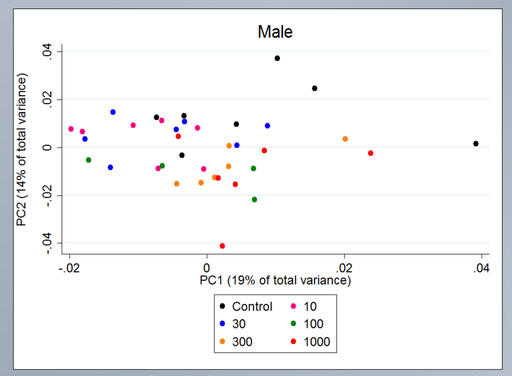

Figure 7: Graph of Principle Component Analysis (PCA) scores for craniofacial shape in males color coded by dose group.

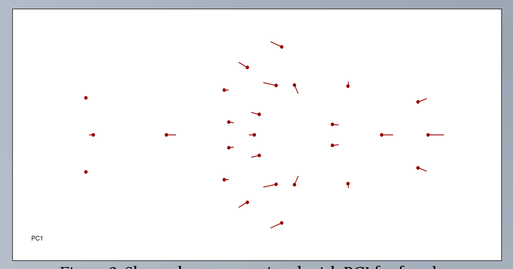

Figure 8: Shape changes associated with PC1 for females.

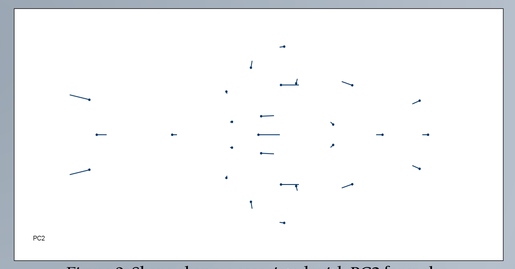

Figure 9: Shape changes associated with PC2 for males.

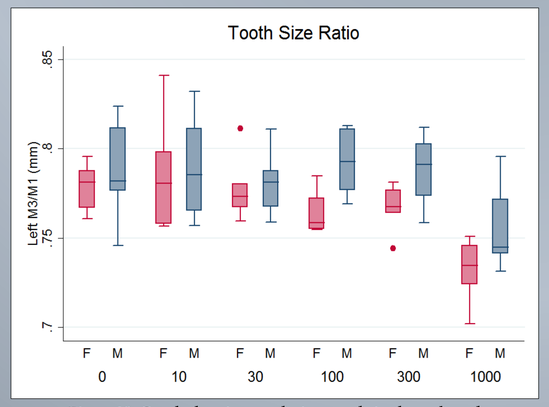

Figure 10: Graph showing tooth size trends in the male and female molar ratio.

Early life exposure to PCB-180 had no effects on male or female adult cranial size in our sample of rats and minor effects on shape. For both sexes, there were significant effects on tooth size, with decreases in females and increases in males, and absence of the interfrontal bone in all high dose groups (i.e., 100-1000 mg/kg body weight).

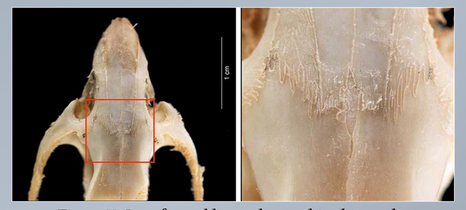

Figure 11: Interfrontal bone observed in this study.

Sex	n	Dose	Interfrontal bone
F	7	0	2/7
F	7	10	1/7
F	5	30	0
F	7	100	0
F	7	300	0
F	5	1000	0
M	7	0	1/7
M	7	10	0
M	9	30	1/9
M	7	100	0
M	6	300	0
M	7	1000	0

Figure 12: Table of interfrontal bone frequency by sex and dose group.

Discussion and Conclusion

Rats and a variety of other animals have exhibited dental defects and changes in craniofacial shape and size when exposed to DL compounds such as TCDD *in utero*. Our results are consistent with these effects with the exception of an effect on craniofacial size. PCB 180 has a distinct lack of effect on craniofacial size in rats. This may be due to weaker systemic toxicity compared with TCDD, the most potent member of the dioxin family. This study has also shown males to be more sensitive to and strongly affected by PCB 180 exposure which is inconsistent with DL effects. This may result from adverse effects on bone size and mineralization occurring only in males and is consistent with a previous study on hepatic effects showing that males are more sensitive to the PCB 180 congener[5].

Ashly Romero (left) and Sabrina Sholts (right).

While we conclude that craniofacial size remains unaffected by PCB 180 exposure, our results indicate that craniofacial shape and tooth size are influenced by treatment, especially in males. This study served to provide more information about PCB 180 specifically, and does not necessarily apply to environmental conditions where synergistic effects take place because of the PCB mixtures that exist naturally.

Photo credit: Jim DiLoreto

Acknowledgements

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