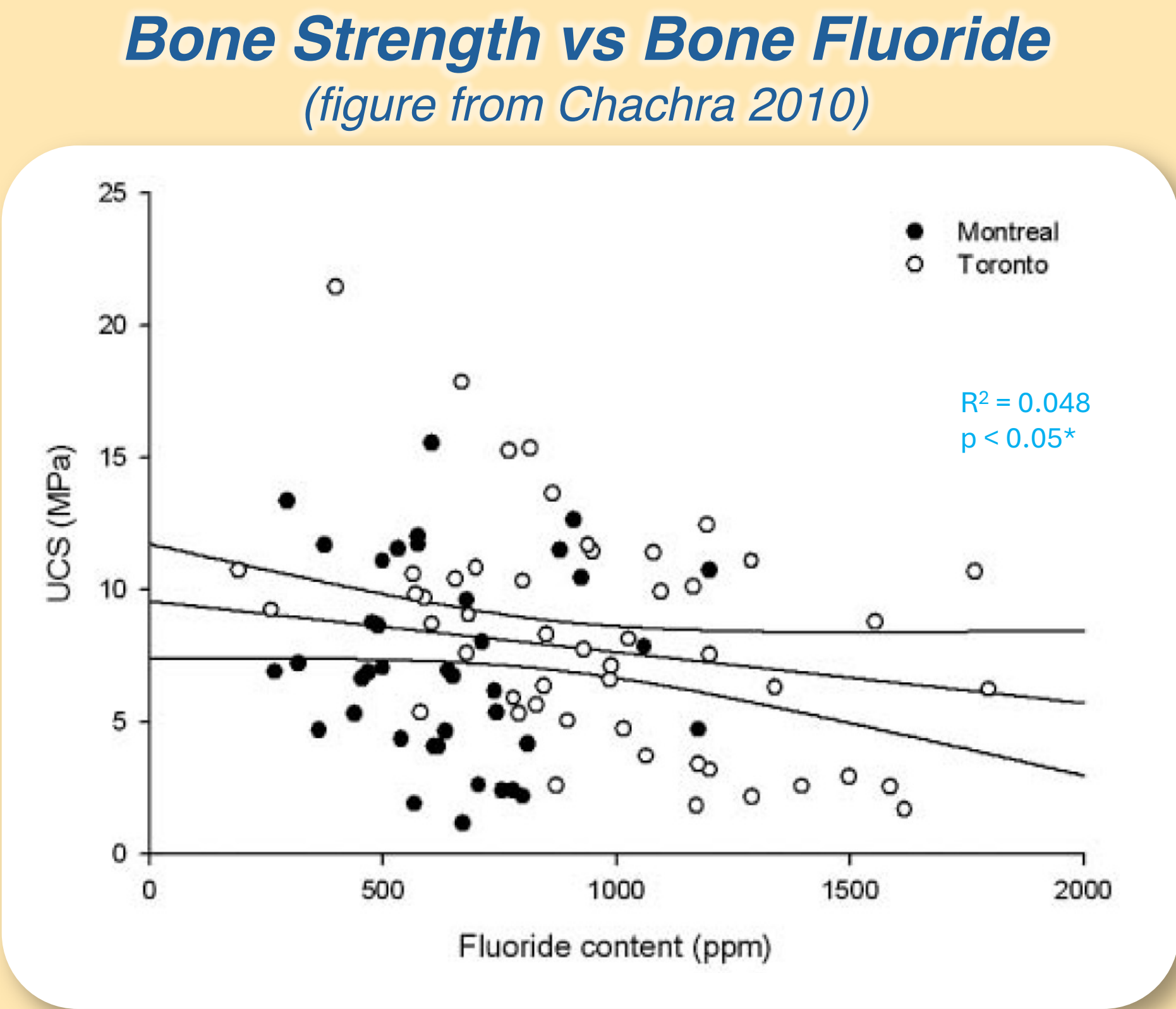
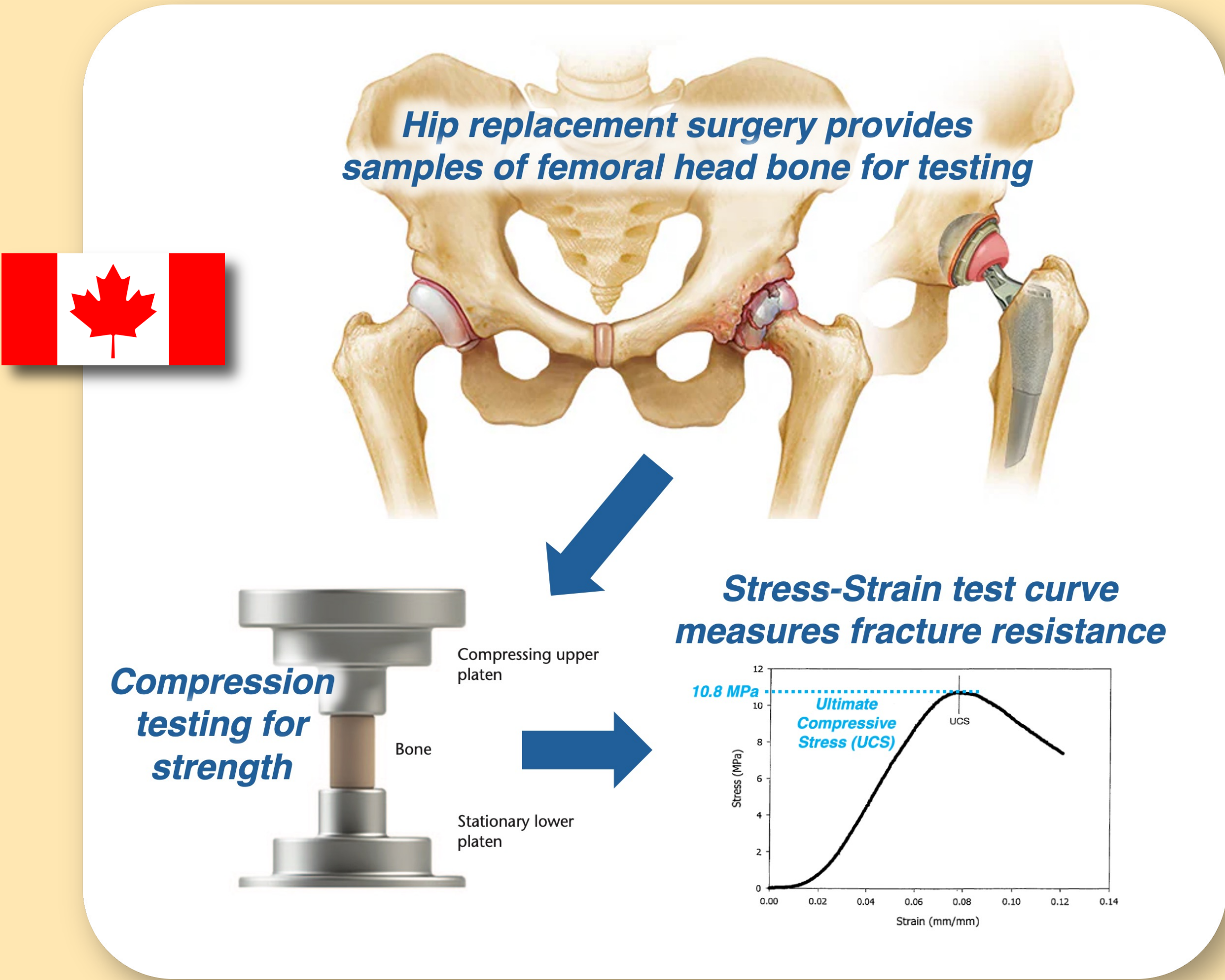


# Fluoride Harms Bone Strength

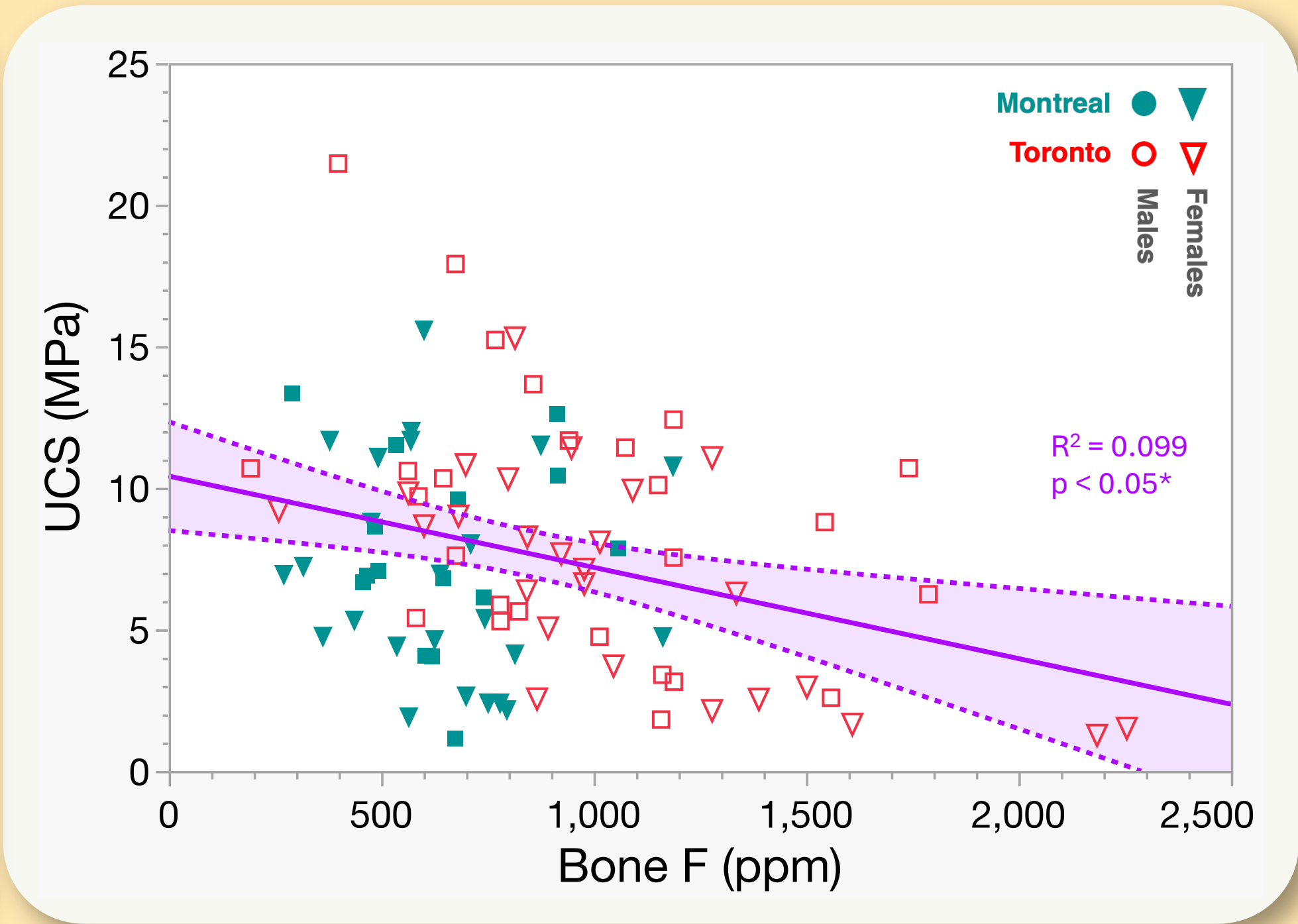
Re-analysis of **bone fluoride's** association with **bone strength**, controlling for confounders, based on bone samples from Canadian hip-replacement-surgery patients.

Chris Neurath<sup>1</sup>, Hardy Limeback<sup>2</sup>, Michael Connett<sup>3</sup>

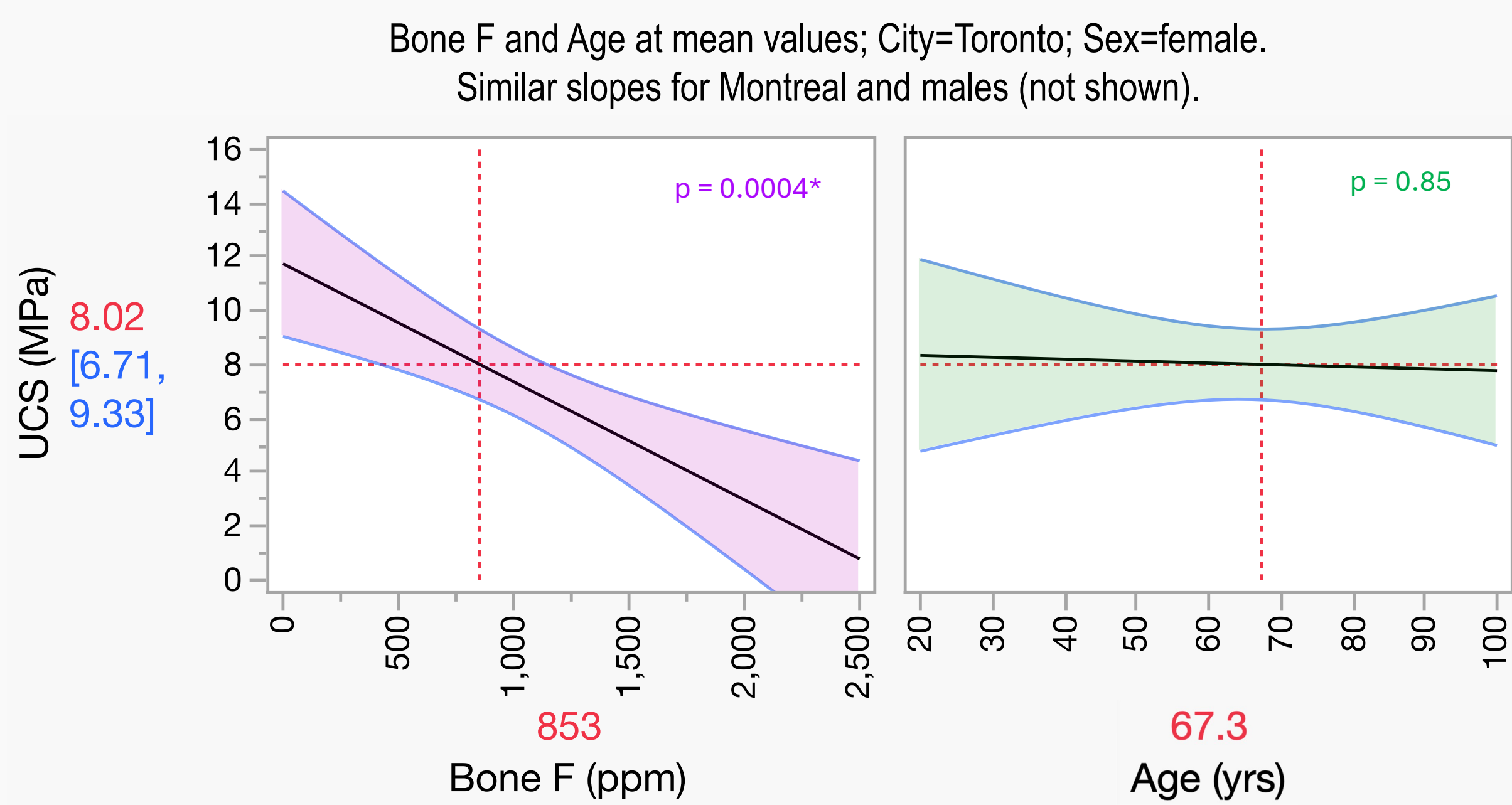
1 American Environmental Health Studies Project (AEHSP), North Sutton, NH  
2 Professor Emeritus, Univ. of Toronto, Faculty of Dentistry, Toronto, Ontario  
3 Siri & Glimstad LLP, Los Angeles, CA



**Bivariate model, Bone Strength vs Bone Fluoride including 2 highest bone F**  
(data extracted from Chachra 2010, 2001)



**Multivariable linear regression model Bone Strength vs Bone Fluoride controlling for City, Sex, and Age**  
(data extracted from Chachra 2010, 2001)



## Conclusions:

- After controlling for Age, City, and Sex, the adverse association between bone fluoride and weaker bone increased in magnitude and statistical significance.
- Age does not explain the relationship between bone fluoride and bone strength.

## Summary

**Objective:** Recent studies of US children and Swedish postmenopausal women found associations between commonly experienced fluoride exposures ( $\leq 1\text{mg/L}$ ) and increased risk of bone fractures [Lindsay et al 2023, Helte et al 2021]. While these studies estimated exposures from drinking water or urine fluoride concentrations, bone fluoride is a more direct measure of long-term exposure to the target tissue. We therefore re-analyzed published data on bone fluoride and bone strength from a study of bone samples obtained from 92 patients undergoing hip replacement surgery in fluoridated Toronto and non-fluoridated Montreal, adding control for age, sex, and city which the original study did not control for [Chachra et al 2010, Chachra 2001].

**Material and Methods:** Data was extracted from published scatterplots using digitizing software, and matched across variables common to two or more scatterplots to determine variable values for each patient. Our re-analysis assessed bone strength (Ultimate Compressive Stress or UCS) as a function of bone fluoride concentration, controlling for age, sex, and city using Generalized Linear Models.

**Results:** Higher bone fluoride had a large and highly significant association with reduced bone strength measured as UCS when controlling for age, sex, and city. The model predicted a decrease in UCS from 10.9 to 3.0 MegaPascals (MPa) as bone fluoride increased from 200 to 2,000 ppm. In the multivariable model, age had no effect on bone strength; estimated UCS for Montreal was 1.1 MPa lower than Toronto; and females had 0.6 MPa lower UCS than males.

**Conclusion:** Bone fluoride had a large and significant adverse association with bone strength after controlling for age, sex, and city. This adverse association found in human bone samples is consistent with the increased risk of bone fractures found in both children and postmenopausal women in two recent epidemiological studies where the main exposure source was also water fluoride  $\leq 1\text{mg/L}$ .

Chachra D, Limeback H, Willett TL, Grynpas MD. The long-term effects of water fluoridation on the human skeleton. *J Dent Res*. 2010;89(11):1219-1223.  
Chachra D. The Influence of Lifelong Exposure to Environmental Fluoride on Bone Quality in Humans [dissertation]. Toronto, Canada: Univ. of Toronto; 2001.  
Helte E, Donat Vargas C, Kippler M, Wolk A, Michaëlsson K, Akesson A. Fluoride in Drinking Water, Diet, and Urine in Relation to Bone Mineral Density and Fracture Incidence in Postmenopausal Women. *Environ Health Perspect*. 2021;129(4):47005.  
Lindsay SE, Smith S, Yang S, Yoo J. Community Water Fluoridation and Rate of Pediatric Fractures. *J Am Acad Orthop Surg Glob Res Rev*. 2023;7(10).

## Multivariable Regression Model

Generalized Linear Model Fit  
n = 91 Response: Ultimate Compressive Stress, UCS (MPa)

### Parameter Estimates

Term	Beta	Lower 95%CI	Upper 95%CI	Prob > ChiSq
Bone F (per 100 ppm)	-0.40	-0.70	-0.20	0.0004
City (ref = Toronto)	-1.07	-1.99	-0.15	0.0229
Sex (ref = Male)	-0.63	-1.42	-0.16	0.1160
Age (yrs)	-0.007	-0.080	-0.066	0.8468