

Dental Age determination

Comments from Home Office Science

This document is in two parts: firstly an assessment based on publicly available information of the nature of the proposed trial and some explanation of the dental process and its ramifications; and secondly a note from the Chief Scientific Adviser on some specific points.

Summary

- The trial is not a scientific investigation of dental age estimation. Its aim is to explore whether a particular technique (dental age estimation) has any relevant contribution to make to a legal and administrative process (the assessment of age by a local council). The trial cannot aim or claim to tell us anything about dental age estimation as such.
- Dental age estimation cannot give certainty or even strong evidence about the age of an individual except within a wide margin of error. It will frequently misclassify children as adults and adults as children.
- The current process (Merton-compliant age assessment) does not appear to have any independent scientific validation but is generally accepted within the legal and administrative framework. The point of the trial is to investigate whether dental age estimation will add information of value to this process in practice.
- We have identified the following risks in carrying out the trial:
 - Concerns expressed publicly, including in legal contexts, about the use of dental (and also bone age) estimates in any legal framework, in view of their quantifiable uncertainty; these could be mitigated if appropriate legal/administrative advice is taken to demonstrate that such evidence will not be ruled out *prima facie* (ie in advance of any detailed discussion of a case).
 - Scientific concerns about the work of Professor Roberts and about the possibility that he may express his views in ways not wholly supported by his own data base (see CSA comments for more details).
 - The use of analyses based on data that are not in the public domain; this could be mitigated if Professor Roberts will publish his data base.
 - The use of a data base from ethnic groups other than those of the subject in question.
 - Concerns, whether or not scientifically justified or credible, about any use of ionising radiation in a non-therapeutic context, especially if the subjects are, or might be, children.

Age assessment trial

What sort of research is this trial?

The trial is a practical experiment to investigate how far the use of dental approaches, as offered within the framework of the trial, can complement the current Merton compliant age assessment and contribute to the overall legal and administrative process of age assessment in a UK Border Agency context. In particular it examines social issues such as:

- Are candidates willing to undertake the dental estimation process?
- Do bodies such as local authorities have any appetite to revise their findings in the light of these estimates? and
- How do the results of dental age estimation impact any legal decisions or proceedings?

This trial is not amenable to a “randomised control” approach, because dental assessment will be offered to all relevant individuals. There is no control group because if individuals, already assessed as 18 or over, choose not to take up the assessment, their status as adults will not be investigated further; on the other hand it would, arguably, be unethical to refuse an individual the opportunity of challenging their assessment as an adult by not offering the dental assessment if it is available. Finally the dental estimation will not be offered to any individuals already assessed as children by the Merton-compliant process.

The numbers involved will be too small to treat the trial as “quantitative” research. Instead, participants in the trial will be regarded as case studies leading to a qualitative assessment of the practicability of the approach more generally. For these case studies to be useful, it is important that as much relevant information as possible is collected on each one, and that is part of the protocol of the trial. Drawing common threads and themes from the various case studies will be an important part of the work.

Anthropometric age estimation: general remarks

Dental age estimation is one of a number of anthropometric methods of estimating age. These are methods based on observations or measurements of the human body. Others include measures of skeletal development (such as using MRI or X-ray) or pubertal maturity.

Anthropometric methods give an estimate of “physical age” as opposed to chronological age. Different people mature and age at different rates, so there is natural variation between physical age and chronological age.

At the ages in question it is very easy for physical age and chronological age to differ by two or even three years in either direction. This is not just the way that people “look” but is to do with all aspects of their physical development. This is about human diversity, not any “error” in anthropometric approaches. For instance, whatever anthropometric measure is used, it is easy for three individuals, one 16, one 18, one 20, say, to have identical “physical ages”. If a person is close to their 18th birthday, no type of physical measurement can determine if they are under or over 18. No physical processes can ever give an exact estimate of chronological age, nor do

they claim to. Estimates will be made in the form of probability or confidence statements. Anthropometric methods therefore provide an honest statement of the intrinsic uncertainty of age estimation, even though at the end of the process a legal or administrative decision has to be made one way or the other.

Dental age estimation

The essence of Professor Roberts's method is as follows. On the basis of a dental X-ray, the stage of development of the root of each tooth is rated on a scale from A to H, where H is the final stage. The key observation relevant to the trial is the stage of development of the lower left third molar (wisdom tooth), which reaches stage H around the age in question. Professor Roberts will support a claim that the person is a child if their lower left third molar has not reached the final stage H. Professor Roberts has a large database of dental X-rays obtained from patients of known ages which he has used to develop his methodology and can be used to quantify its performance.

Because of the fundamental uncertainty in the match between chronological and biological age, there will always be a trade-off in the two possible errors:

- A. Misclassifying a child as an adult: In a document submitted to the Australian Human Rights Commission, the statistician Professor Tim Cole gives a more detailed analysis¹ of Professor Roberts's database. In Cole's analysis, a child coming up to 18 has a chance of about 24% of having a mature wisdom tooth. A child aged exactly 17 (ie on their 17th birthday) would have a chance of 13% and one aged exactly 16 a chance of 7%. These probabilities are based on Professor Roberts's samples of Caucasian children. According to Professor Roberts's anecdotal statements, South Asian and Chinese children have lower probabilities of mature teeth at these ages, while there is a suggestion that African-Caribbean children have higher probabilities.
- B. Misclassifying an adult as a child: There are individuals well beyond their 20th birthday in Professor Roberts's data who still have immature wisdom teeth. Cole's analysis indicates that about half of "young adults" (the 18-20 age group) will be misclassified as children by the Roberts assessment. The remarks above about children of South Asian and Chinese descent suggest this proportion may be higher for that ethnic background.

In summary, Cole's analysis indicates that the Roberts method will, for Caucasians,

- classify about 20% of 17 year olds as "adults"
- classify about 50% of young adults as "children."

Professor Roberts's anecdotal statements suggest that, other things being equal, African-Caribbean children are more likely to be classified as adults and South Asian and Chinese children less likely.

Every anthropometric method will have a similar trade-off and the likely error will be more acute the nearer, in either direction, an individual is to their 18th birthday. In any case, the UK Border Agency / Croydon Council trial does not aim to assess the

¹*Australian Human Rights Commission: Inquiry into the treatment of individuals suspected of people smuggling offences who say they are children*, Submission by Tim J Cole, see download at: <http://www.hreoc.gov.au/ageassessment/submissions.html>

accuracy of Professor Roberts's estimates or other anthropometric methods. Indeed it cannot do that, because the true ages of the individuals in the trial are not known.

The Merton compliant age assessment process

The Merton compliant age assessment process does not use physical measurements, and we know of no research which validates the Merton compliant process by applying it to individuals whose age is known. (Indeed it may not be possible to find a representative population of suitable volunteer subjects to carry out such research.) So it is not possible to quantify its misclassification rates.

Ethical issues surrounding dental X-rays: scientific background

Detailed discussion of the actual ethical issues of the use of dental X-rays is beyond the scope of this note. However the following background may be helpful:

Radiation doses are measured in milliSieverts (mSv) but for comparability are more clearly expressed as a multiple of the natural background radiation we receive all the time. A panoramic dental X-ray has an effective dose equivalent to about 1.5 days of average UK background radiation.² This is about half the dose received on a transatlantic flight.³ The natural radiation level varies very considerably in different geographical locations, for geological and other natural reasons. For example in Finland it is on average over three times than in the UK,⁴ so spending a single day in Finland rather than the UK will give a larger additional dose of radiation than a panoramic dental X-ray.

A recent study (Claus et al, 2012^[1]) suggests a possible link between dental X-rays and a normally benign tumour called *meningioma*. The conclusions of this paper have been disputed, for reasons presented on the American Dental Association website^[2], but nevertheless it may be quoted by those with concerns about the trial.

² Health Protection Agency, *Patient dose information*,
http://www.hpa.org.uk/web/HPAweb&HPAwebStandard/HPAweb_C/1195733826941

³ Health Protection Agency, *Dose comparisons for ionising radiation*,
<http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/UnderstandingRadiationTopics/DoseComparisonsForIonisingRadiation>

⁴ Health Physics Society, *Answer to question #1097 submitted to "ask the experts,"*
<https://hps.org/publicinformation/ate/q1097.html>

^[1] Claus, E. B., Calvocoressi, L., Bondy, M. L., Schildkraut, J. M., Wiemels, J. L. and Wrensch, M. (2012), 'Dental x-rays and risk of meningioma.' *Cancer*. doi: 10.1002/cncr.26625

^[2] American Dental Association, Press Release 10 April 2012, 'Recent Study Questions Safety of Dental X-Rays,' <http://www.ada.org/6972.aspx>

Chief Scientific Adviser's comments

1. I have met with Professor Roberts (PGR) and his team, have reviewed their publications, and have been provided with a copy of part of their data base.
2. I am not wholly convinced by the way that PGR uses his data base to arrive at statistical conclusions. His professionalism as a dentist is not in doubt. But his methods have come under some public criticism from a statistical point of view. Because of these concerns, it would make sense for transparency for PGR to put his entire data base into the public domain so that anyone who wished to reanalyse it would be able to do so. It would also dispel any criticism at ethical review stage of the use of a methodology whose scientific basis was not right out in the open.
3. If someone presents with a lower left wisdom tooth not yet at Stage H, PGR will assert that with high probability this individual is under 18. As far as I can understand from conversations with him and his team, this is because, within his data base, most of those with the tooth at Stage G (the penultimate stage) are under 18, while most of those with teeth at Stage H are over 18. For reasons familiar to any professional statistician, PGR's conclusion cannot be drawn in general, because it only holds under the assumption that the individual is drawn from a population with the same overall age distribution as the data base, an assumption which cannot be made in the context of the trial.
4. On the other hand we can use PGR's data base to find the distribution of the age at which the tooth moves to stage H. My own analysis⁵ of the data indicates that (in round terms) this happens in 10% of individuals before age 18; in 50% at age 18 or 19; in 30% at age 20 or 21; and in 10% after their 22nd birthday.
5. The consequence of this for PGR's methodology is worrying. It means that most people will continue to be classified by PGR as children well beyond their 18th birthday, typically for up to two years and sometimes for more than four years.
6. If someone of Caucasian ethnicity presents with a mature LL8 tooth, then PGR's data base would enable me to assert with 90% confidence that they were over 18. But this is not an overwhelming level; there are 14 year olds in the data base with mature LL8 (and this is more likely for young people of African-Caribbean origin according to informal conversation with PGR).
7. Conversely, if their tooth was immature, I would be 90% confident that they were under 22. But these are people who would be classified by PGR as children. So PGR would be prepared to make a much stronger statement than I would.⁶

⁵ These figures differ slightly from those in Professor Tim Cole's published analysis. The reason is that Cole fits a model to the data (a standard logistic regression) while my figures are derived simply from the raw data. The broad conclusions are identical whichever method is used.

⁶ Unfortunately this is not the only area where I would take issue with the statistical arguments of PGR and his team. For age assessment at younger ages, they have an approach which uses several of the subject's teeth, combining evidence on all of these to get a single result. Their approach is via the methodology of meta-analysis, which is traditionally used to combine results from a number of published medical studies. A key assumption of meta-analysis is that the studies are independent of one another; but in the case of a number of teeth from the same subject, this independence assumption does not hold.

8. In the case of the proposed trial, this puts us in an interesting position. The trial will only include subjects who have been assessed by the Merton compliant process as adults but assert that they are children. So there are two possible outcomes for a subject in the trial:
 - A. **PGR finds they have a mature LL8 and therefore classifies them as an adult:** In this case there will be no further action because all the evidence points the same way. The advantage will be a stronger case to deny the subject's claim, but it should be noted that the doubt about their age is not dispelled completely by the dental estimation.
 - B. **PGR finds an immature LL8 and therefore states that with high probability this subject is a child.** The problem is that this can easily happen if their true age is in the range 18 to 22. Because (in my view) PGR presents his results in a way that give exaggerated support to the "child" possibility, the risk is that the Local Authority will be too easily persuaded. It is therefore important that the Local Authority should revisit their previous assessment but not automatically change it. If the Local Authority simply "caves in" then there will be the risk of substantial misclassifications of younger adults as children.
9. The Association of Forensic Science Providers publishes standards⁷ for the presentation of evidence of the kind that the dental X-rays can provide. This gives terminology that is appropriate for particular strength of statistical evidence. If this terminology is applied, the following conclusions can be drawn.
 - A. **PGR finds a mature LL8:** There is moderate support for the assertion that the individual is over about 17 years 9 months.
 - B. **PGR finds an immature LL8:** There is moderate support for the assertion that the individual is under about 22 years 3 months.
10. There is a need for more careful consideration of variation across different ethnic groups, given that PGR's current data base consists of individuals of Caucasian ethnicity. It is worth noting that the research student Susan Parekh, jointly supervised by PGR and Professor Tim Cole, remarked in her doctoral thesis that "[e]stimating age for individuals of different ethnic origin against standards derived from European populations is of limited value, as it may disadvantage the applicant. If a particular ethnic group is shown to mature faster, then comparing them with other ethnic groups may suggest that they are older than their chronological age." (2011, p 44-45).

⁷ Association of Forensic Science Providers (2009), Standards for the formulation of evaluative forensic science expert opinion, *Science and Justice* **49**, 161-164.