The changing face of orthodontics

Many of us have had our teeth straightened with braces. Few people know, however, that orthodontics involves a great deal of fundamental science and fast-moving technology.

By Sophie and Georges Rozencweig

Most of us are familiar with orthodontics as a kind of mechanical engineering inside the mouth – all those metal braces, plates and wires. But how many of us are aware of the different sciences involved in this area of dentistry? Today’s orthodontists have to understand and apply a good deal of specialist science – everything from genetics to metallurgy.

What is orthodontics?

Orthodontics is the branch of dentistry concerned with diagnosing and correcting irregularities of the teeth and jaws. It is used for far more than achieving a perfect Hollywood smile: our jaws and teeth are used for talking as well as chewing, so orthodontics is concerned with how facial anatomy affects these functions, as well as with cosmetic improvements.

As orthodontists, we are always seeking the latest insights and techniques from relevant scientific fields and applying them to our work.

In this article we will look at several examples. Some are on the opposite page.
Physics:
many orthodontic resins
can be cured (polymerised)
using light. Four main types
of polymerising light source
are available: halogen bulbs,
plasma arc lamps, argon ion
lasers, and light-emitting
diodes.

Growth and development:
faces change as they
mature and age, due to
alterations in body tissues.
Understanding these
processes allows us to
positively influence
them.

Genetics:
we need to be
able to diagnose
whether a problem
has a genetic cause,
so we can treat it
effectively.

Metallurgy and
materials science:
as well as metals, we use
alginites and silicones for taking
impressions, composites and glass
ionomer cements for sealing and
sticking, plaster for making casts,
and resins for creating removable
appliances. We need to understand
each material’s physical and
chemical properties to use them
in the best way for
each patient.

Radiology:
radiographs help us to
diagnosis complex problems.
We use many different types of
radiographs, to provide views from
different angles (frontal, profile or
panoramic) or exploit different
imaging techniques (scanners,
magnetic resonance imaging
and cone beam computed
tomography).

Biology:

Everybody has an experience of visiting the dentist: for
some, these visits involve nothing more than a quick
poke around and a polish; for others, it can be a very
traumatic experience.

However, to what extent do we understand the role
of a dentist? In the UK, all dentists must undergo a 5-year
period of study to gain a primary dental qualification.
Those who wish to specialise in orthodontics will need
both dentistry experience and a further 3-year specialist
qualification. In addition to clinical training and
practice, the dental student will learn about molecular
biology, anatomy and physiology, materials science
and human disease. As a dental student with whom I
was at university put it, “It’s all connected, you know!”
Dentistry is a career many young people choose to
study at university. However, certainly in UK schools,
very little (if any) time is spent studying the mouth,
teeth or dental science. This article provides excellent
reading material for those students who are thinking
about a career in dentistry. It could be used by teachers
to provide an introduction to dentistry and its subspecialties,
and to help students make an informed choice
about their prospective careers.

In addition, the article provides an alternative context
for biology lessons on transcription and translation of
DNA, cell signalling and cell differentiation, and toti-
potent stem cells. Teachers may wish to use the article
as a basis for a group discussion or research project;
alternatively they may wish to recommend it as back-
ground reading material before the commencement of
teaching. For physics and materials science lessons,
the article also provides an insight into real-life appli-
cations of alloys, composites and smart materials.
In a social context, the article can serve as a basis to
discuss health care in the developing world, using the
treatment of cleft palates as an example.

Jonathan Schofield, McAuley Roman Catholic High
School, Doncaster, UK

www.scienceinschool.org

Science in School • Issue 25 : Winter 2012 • 55
Genetics and molecular biology in orthodontics

Some of the problems that orthodontists deal with are genetic in origin (figure 2). Although most of these are minor, others result from genetic abnormalities in the way that the head and face develop before birth\(^1\). In the embryo, the development of facial structures begins with neural crest cells forming at the site of the brain. These cells then migrate to form a tissue that differentiates into cells called osteoblasts, chondroblasts and odontogenic cells. These then develop to form the hard tissues of the head and neck – the bones, cartilage and teeth.

During this process, molecules called signalling factors and transcription factors play an important part. Signalling factors are a cell’s way of triggering a response in another cell, while transcription factors control which specific DNA sequences are used to produce mRNA and thus proteins. For example, we now know that if the signalling factor TGF-\(\beta\) is inactive, this causes cleft palates\(^2\) and upper jawbone malformations. Mutations in the receptor sites (where the response is triggered) for the signalling factor FGF also cause a large number of craniofacial abnormalities.

Another example is the transcription factors associated with the homeobox genes. These transcription factors are especially important in enabling the neural crest cells to develop into the skeletal structures of the head and face, so defects in the way these genes are transcribed can lead to abnormalities in facial development.

Another example of the importance of molecular biology to orthodontics is the recent discovery that dental pulp (the area of connective tissue at the centre of a tooth) contains valuable adult stem cells, which can be induced to form other types of cells. Thus when a tooth is extracted or falls out, the stem cells may be harvested and stored for future treatment. Stem cells are already being used to treat some cancers, and additional applications may be on the horizon. For example, researchers are exploring whether stem cells can be used to grow a natural replacement for a missing tooth.

Biomechanics and orthodontics

The amount of force needed to move a tooth depends on its size and the type of movement (turning or sliding). The moving force also needs...
an anchor, so a group of teeth and appliances are selected and used as anchorage (figures 3 and 4).

As orthodontists, our task is to decide on the best combination of forces and anchorage to achieve the right movements, without any adverse effects. We review each stage of treatment to make sure this is happening; if it is not, we need to change the treatment plan.

In traditional orthodontics, appliances such as headgear and intra-oral elastics are used to reinforce anchorage, which require a good deal of patient co-operation. Today, titanium mini-screws can be used instead in some cases (figure 4).

**Metallurgy and orthodontics**

The forces used in orthodontics come from the archwires (figure 5). At the beginning of the treatment, the wires need to be quite elastic to start individual teeth moving. Later on, the wires have to be more rigid to ensure stability while a whole block of teeth is moved.

Orthodontists can choose wires made from a variety of metallic materials:

- **Stainless steel**: this is easy to shape and has high rigidity so it provides stability.
- **Nitinol alloys**: these nickel-titanium alloys have very high elasticity. They produce a weak but constant force suitable for the initial alignment phases. However, they cannot be soldered.
- **Shape-memory alloys**: these metals have variable elasticity depending on the temperature. They can be bent for insertion into the mouth; once there, they ‘try’ to recover their initial shape, exerting a force on the teeth.

**A dynamic discipline**

As you can see, orthodontists need to be good all-round scientists to keep up with the changing knowledge and technological innovations in their discipline. So, if a student in your class misses a science lesson because of an appointment with an orthodontist, don’t worry – it might be the perfect opportunity to learn about the latest findings in molecular biology, or provide inspiration to a budding materials scientist.
Web references


w2 – This animation shows how a cleft palate develops (voiceover in Russian). http://youtu.be/WAU13syh-w4

w3 – The website of the UK’s National STEM Centre offers a free downloadable booklet about metals and shape-memory alloys, together with suggestions for teachers on how to introduce the ideas in the classroom, plus student activity sheets and notes for teachers and technicians. See: www.tanos.co.uk/braces/bkb

The website of the British Orthodontic Society offers information about education and research as well as careers in orthodontics. See: www.bos.org.uk

Dentistry has a surprisingly long history. Recently, a filling was found in the fossilised jawbone of a man who lived 6500 years ago in what is now Slovenia. To learn more, see: Bernardini F et al. (2012) Beeswax as dental filling on a Neolithic human tooth. PLOS One 7(9): e44904. doi:10.1371/journal.pone.0044904

PLOS One is an open-access research journal, so this and all other articles in it are freely available.

Barras C (2012) Oldest dental filling is found in a Stone Age tooth. New Scientist. www.newscientist.com or use the direct link: http://tinyurl.com/stoneagefilling


Funded by the European Commission, the Eurostemcell website offers information and educational resources on stem cells and their impact on society. See: www.eurostemcell.org

If you found this article useful, you might like to browse the other medicine-related articles in Science in School. See: www.scienceinschool.org/medicine

Sophie and Georges Rozencweig both trained in orthodontics in Paris, France, after which they gained master’s degrees in orthodontics from Case University in Cleveland, Ohio, USA. Since 1991, they have shared an orthodontic practice in Grenoble, France.

Both Georges and Sophie are involved in continuing education: they give university lectures, write articles for publication and are on the editorial board of several French orthodontic journals. Georges is the editor of the journal l’Orthodontie Française.

Resources

The Archwired website (www.archwired.com), maintained by an adult wearer of orthodontic braces, hosts articles on various orthodontic topics. See: www.archwired.com

For example, how braces work (www.archwired.com/how_braces_work.htm) or a brief history of orthodontics (www.archwired.com/HistoryofOrtho.htm).

Another short history of orthodontics is available on the About.com website (http://inventors.about.com) or via the direct link: http://tinyurl.com/9n2f8cw

The Braces Knowledge Base website, also maintained by a braces wearer, offers comprehensive illustrated information about orthodontic devices. See: www.tanos.co.uk/braces/bkb

The website of the British Orthodontic Society offers information about education and research as well as careers in orthodontics. See: www.bos.org.uk

Dentistry has a surprisingly long history. Recently, a filling was found in the fossilised jawbone of a man who lived 6500 years ago in what is now Slovenia. To learn more, see: Bernardini F et al. (2012) Beeswax as dental filling on a Neolithic human tooth. PLOS One 7(9): e44904. doi:10.1371/journal.pone.0044904

PLOS One is an open-access research journal, so this and all other articles in it are freely available.

Barras C (2012) Oldest dental filling is found in a Stone Age tooth. New Scientist. www.newscientist.com or use the direct link: http://tinyurl.com/stoneagefilling


Funded by the European Commission, the Eurostemcell website offers information and educational resources on stem cells and their impact on society. See: www.eurostemcell.org

If you found this article useful, you might like to browse the other medicine-related articles in Science in School. See: www.scienceinschool.org/medicine

Sophie and Georges Rozencweig both trained in orthodontics in Paris, France, after which they gained master’s degrees in orthodontics from Case University in Cleveland, Ohio, USA. Since 1991, they have shared an orthodontic practice in Grenoble, France.

Both Georges and Sophie are involved in continuing education: they give university lectures, write articles for publication and are on the editorial board of several French orthodontic journals. Georges is the editor of the journal l’Orthodontie Française.

Resources

The Archwired website (www.archwired.com), maintained by an adult wearer of orthodontic braces, hosts articles on various orthodontic topics. See: www.archwired.com

For example, how braces work (www.archwired.com/how_braces_work.htm) or a brief history of orthodontics (www.archwired.com/HistoryofOrtho.htm).

Another short history of orthodontics is available on the About.com website (http://inventors.about.com) or via the direct link: http://tinyurl.com/9n2f8cw

The Braces Knowledge Base website, also maintained by a braces wearer, offers comprehensive illustrated information about orthodontic devices. See: www.tanos.co.uk/braces/bkb

The website of the British Orthodontic Society offers information about education and research as well as careers in orthodontics. See: www.bos.org.uk

Dentistry has a surprisingly long history. Recently, a filling was found in the fossilised jawbone of a man who lived 6500 years ago in what is now Slovenia. To learn more, see: Bernardini F et al. (2012) Beeswax as dental filling on a Neolithic human tooth. PLOS One 7(9): e44904. doi:10.1371/journal.pone.0044904

PLOS One is an open-access research journal, so this and all other articles in it are freely available.

Barras C (2012) Oldest dental filling is found in a Stone Age tooth. New Scientist. www.newscientist.com or use the direct link: http://tinyurl.com/stoneagefilling

To learn more about how light can be used in polymerisation, see: Douglas P, Garley M (2010) Chemistry and light. Science in School 14: 63-