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Saturday, December 11, 2010

Dr. Mellanby's Tooth Decay Reversal Diet

I have a lot of admiration for Drs. Edward and May Mellanby. A husband-and-wife team, they discovered vitamin D, and determined that rickets is caused by poor calcium (or phosphorus) status, typically due to vitamin D deficiency. They believed that an ideal diet is omnivorous, based on whole foods, and offers an adequate supply of fat-soluble vitamins and easily absorbed minerals. They also felt that grain intake should be modest, as their research showed that unsoaked whole grains antagonize the effect of vitamins D and A.

Not only did the Mellanbys discover vitamin D and end the rickets epidemic that was devastating Western cities at the time, they also discovered a cure for early-stage tooth decay that has been gathering dust in medical libraries throughout the world since 1924.

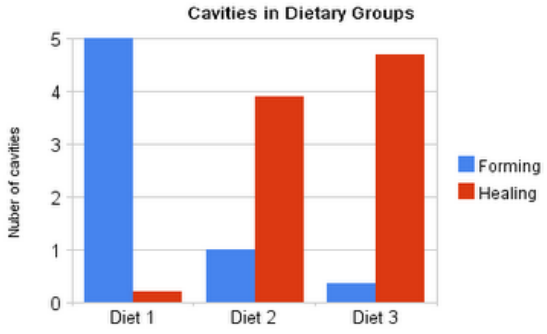
It was in that year that Dr. May Mellanby published a summary of the results of the Mellanby tooth decay reversal studies in the British Medical Journal, titled "Remarks on the Influence of a Cereal-free Diet Rich in Vitamin D and Calcium on Dental Caries in Children". Last year, I had to specially request this article from the basement of the University of Washington medical library (1). Thanks to the magic of the internet, the full version of the paper is now freely available online (2).

You don't need my help to read the study, but in this post I offer a little background, a summary and my interpretation.

In previous studies, the Mellanbys used dogs to define the dietary factors that influence tooth development and repair. They identified three, which together made the difference between excellent and poor dental health (from *Nutrition and Disease*):

1. The diet's mineral content, particularly calcium and phosphorus
2. The diet's fat-soluble vitamin content, chiefly vitamin D
3. The diet's content of inhibitors of mineral absorption, primarily phytic acid

Once they had defined these factors, they set about testing their hypotheses in humans. They performed eight trials, each one in children in an institutionalized setting where diet could be completely controlled. The number of cavities in each child's mouth was noted at the beginning and end of the period. I'll only discuss the three most informative, and only the most successful in detail. First, the results:



I'll start with diet 1. Children on this diet ate the typical fare, plus extra oatmeal. Oatmeal is typically eaten as an unsoaked whole grain (and soaking it isn't very effective in any case), and so it is high in

About Me

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phytic acid, which effectively inhibits the absorption of a number of minerals including calcium. These children formed 5.8 cavities each and healed virtually none-- not good!

Diet number 2 was similar to diet 1, except there was no extra oatmeal and the children received a large supplemental dose of vitamin D. Over 28 weeks, only 1 cavity per child developed or worsened, while 3.9 healed. Thus, simply adding vitamin D to a reasonable diet allowed most of their cavities to heal.

Diet number 3 was the most effective. This was a grain-free diet plus supplemental vitamin D. Over 26 weeks, children in this group saw an average of only 0.4 cavities form or worsen, while 4.7 healed. The Mellanbys considered that they had essentially found a cure for this disorder in its early stages.

What exactly was this diet? Here's how it was described in the paper (note: cereals = grains):

> ...instead of cereals- for example, bread, oatmeal, rice, and tapioca- an increased allowance of potatoes and other vegetables, milk, fat, meat, and eggs was given. The total sugar, jam, and syrup intake was the same as before. Vitamin D was present in abundance in either cod-liver oil or irradiated ergosterol, and in egg yolk, butter, milk, etc. The diet of these children was thus rich in those factors, especially vitamin D and calcium, which experimental evidence has shown to assist calcification, and was devoid of those factors- namely, cereals- which interfere with the process.

Carbohydrate intake was reduced by almost half. Bread and oatmeal were replaced by potatoes, milk, meat, fish, eggs, butter and vegetables. The diet is reminiscent of what Dr. Weston Price used to reverse tooth decay in his dental clinic in Cleveland, although Price's diet did include rolls made from freshly ground whole wheat. Price also identified the fat-soluble vitamin K2 MK-4 as another important factor in tooth decay reversal, which would have been abundant in Mellanby's studies due to the dairy. The Mellanbys and Price were contemporaries and had parallel and complementary findings. The Mellanbys did not understand the role of vitamin K2 in mineral metabolism, and Price did not seem to appreciate the role of phytic acid from unsoaked whole grains in preventing mineral absorption.

Here are two sample meals provided in Dr. Mellanby's paper. I believe the word "dinner" refers to the noon meal, and "supper" refers to the evening meal:

> Breakfast- Omelette, cocoa, with milk.
> Lunch- Milk.
> Dinner- Potatoes, steamed minced meat, carrots, stewed fruit, milk.
> Tea- Fresh fruit salad, cocoa made with milk.
> Supper- Fish and potatoes fried in dripping, milk.

> Breakfast- Scrambled egg, milk, fresh salad.
> Dinner- Irish stew, potatoes, cabbage, stewed fruit, milk.
> Tea- Minced meat warmed with bovril, green salad, milk.
> Supper- Thick potato soup made with milk.

In addition, children received vitamin D daily. Here's Dr. Mellanby's summary of their findings:

> The tests do not indicate that in order to prevent dental caries children must live on a cereal-free diet, but in association with the results of the other investigations on animals and children they do indicate that the amount of cereal eaten should be reduced, particularly during infancy and in the earlier years of life, and should be replaced by an increased consumption of milk, eggs, butter, potatoes, and other vegetables. They also indicate that a sufficiency of vitamin D and calcium should be given from birth, and before birth, by supplying a suitable diet to the pregnant mother. The teeth of the children would be well formed and more resistant to dental caries instead of being hypoplastic and badly calcified, as were those in this investigation.

If I could add something to this program, I would recommend daily tooth brushing and flossing, avoiding sugar, and rinsing the mouth with water after each meal.

This diet is capable of reversing *early stage* tooth decay. It will not reverse advanced decay, which requires professional dental treatment as soon as possible. It is not a substitute for dental care in general, and if you try using diet to reverse your own tooth decay, please do it under the supervision of a dentist. And while you're there, tell her about Edward and May Mellanby!

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Posted by Stephan Guyenet at 9:00 AM 63 comments

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Labels: dental health, diet, fat-soluble vitamins, low-carb, minerals, phytic acid

Wednesday, December 2, 2009

Malocclusion: Disease of Civilization, Part IX

A Summary

For those who didn't want to wade through the entire nerd safari, I offer a simple summary.

Our ancestors had straight teeth, and their wisdom teeth came in without any problem. The same continues to be true of a few non-industrial cultures today, but it's becoming rare. Wild animals also rarely suffer from orthodontic problems.

Today, the majority of people in the US and other affluent nations have some type of malocclusion, whether it's crooked teeth, overbite, open bite or a number of other possibilities.

There are three main factors that I believe contribute to malocclusion in modern societies:

1. Maternal nutrition during the first trimester of pregnancy. Vitamin K2, found in organs, pastured dairy and eggs, is particularly important. We may also make small amounts from the K1 found in green vegetables.
2. Sucking habits from birth to age four. Breast feeding protects against malocclusion. Bottle feeding, pacifiers and finger sucking probably increase the risk of malocclusion. Cup feeding and orthodontic pacifiers are probably acceptable alternatives.
3. Food toughness. The jaws probably require stress from tough food to develop correctly. This can contribute to the widening of the dental arch until roughly age 17. Beef jerky, raw vegetables, raw fruit, tough cuts of meat and nuts are all good ways to exercise the jaws.

And now, an example from the dental literature to motivate you. In 1976, Dr. H. L. Eirew published an interesting paper in the British Dental Journal. He took two 12-year old identical twins, with identical class I malocclusions (crowded incisors), and gave them two different orthodontic treatments. Here's a picture of both girls before the treatment:

Fig. 1. A, Original appearance of twins; B, original models of twins.

In one, he made more space in her jaws by extracting teeth. In the other, he put in an apparatus that broadened her dental arch, which roughly mimics the natural process of arch growth during childhood and adolescence. This had profound effects on the girls' subsequent occlusion and facial structure:

Nutrition Hall of Fame

Sir Edward Mellanby, M.D., D.Sc.
May Mellanby, D.Sc.
Weston Price, D.D.S.
Sir Robert McCarrison, M.D.
William Lands, Ph.D.
Staffan Lindeberg, M.D, Ph.D.
Mark Nathan Cohen, Ph.D.
Loren Cordain, Ph.D.
Anthony Sclafani, Ph.D.
Michel Cabanac, M.D.

Fig. 3. Post-treatment appearance of twins.

The girl on the left had teeth extracted, while the girl on the right had her arch broadened. Under ideal circumstances, this is what should happen naturally during development. Notice any differences?

Thanks to the Weston A Price foundation's recent newsletter for the study reference.

Posted by Stephan Guyenet at 8:00 PM 37 comments

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Labels: dental health, diet, diseases of civilization

Saturday, November 28, 2009

Malocclusion: Disease of Civilization, Part VIII

Three Case Studies in Occlusion

In this post, I'll review three cultures with different degrees of malocclusion over time, and try to explain how the factors I've discussed may have played a role.

The Xavante of Simoes Lopes

In 1966, Dr. Jerry D. Niswander published a paper titled "The Oral Status of the Xavantes of Simoes Lopes", describing the dental health and occlusion of 166 Brazilian hunter-gatherers from the Xavante tribe (free full text). This tribe was living predominantly according to tradition, although they had begun trading with the post at Simoes Lopes for some foods. They made little effort to clean their teeth. They were mostly but not entirely free of dental cavities:

> Approximately 33% of the Xavantes at Simoes Lopes were caries free. Neel et al. (1964) noted almost complete absence of dental caries in the Xavante village at Sao Domingos. The difference in the two villages may at least in part be accounted for by the fact that, for some five years, the Simoes Lopes Xavante have had access to sugar cane, whereas none was grown at Sao Domingos. It would appear that, although these Xavantes still enjoy relative freedom from dental caries, this advantage is disappearing after only six years of permanent contact with a post of the Indian Protective Service.

The most striking thing about these data is the occlusion of the Xavante. 95 percent had ideal occlusion. The remaining 5 percent had nothing more than a mild crowding of the incisors (front teeth). Niswander didn't observe a single case of underbite or overbite. This would have been truly exceptional in an industrial population. Niswander continues:

> Characteristically, the Xavante adults exhibited broad dental arches, almost

> perfectly aligned teeth, end-to-end bite, and extensive dental attrition. At 18-20 years of age, the teeth were so worn as to almost totally obliterate the cusp patterns, leaving flat chewing surfaces.

The Xavante were clearly hard on their teeth, and their predominantly hunter-gatherer lifestyle demanded it. They practiced a bit of "rudimentary agriculture" of corn, beans and squash, which would sustain them for a short period of the year devoted to ceremonies. Dr. James V. Neel describes their diet (free full text):

> Despite a rudimentary agriculture, the Xavante depend very heavily on the wild products which they gather. They eat numerous varieties of roots in large quantities, which provide a nourishing, if starchy, diet. These roots are available all year but are particularly important in the Xavante diet from April to June in the first half of the dry season when there are no more fruits. The maize harvest does not last long and is usually saved for a period of ceremonies. Until the second harvest of beans and pumpkins, the Xavante subsist largely on roots and palmito (Chamacrops sp.), their year-round staples.
>
> From late August until mid-February, there are also plenty of nuts and fruits available. The earliest and most important in their diet is the carob or ceretona (Ceretona sp.), sometimes known as St. John's bread. Later come the fruits of the buriti palm (Mauritia sp.) and the piqui (Caryocar sp.). These are the basis of the food supply throughout the rainy season. Other fruits, such as mangoes, genipapo (Genipa americana), and a number of still unidentified varieties are also available.
>
> The casual observer could easily be misled into thinking that the Xavante "live on meat." Certainly they talk a great deal about meat, which is the most highly esteemed food among them, in some respects the only commodity which they really consider "food" at all... They do not eat meat every day and may go without meat for several days at a stretch, but the gathered products of the region are always available for consumption in the community.
>
> Recently, the Xavante have begun to eat large quantities of fish.

The Xavante are an example of humans living an ancestral lifestyle, and their occlusion shows it. They have the best occlusion of any living population I've encountered so far. Here's why I think that's the case:

- A nutrient-rich, whole foods diet, presumably including organs.
- On-demand breast feeding for two or more years.
- No bottle-feeding or modern pacifiers.
- Tough foods on a regular basis.

I don't have any information on how the Xavante have changed over time, but Niswander did present data on another nearby (and genetically similar) tribe called the Bakairi that had been using a substantial amount of modern foods for some time. The Bakairi, living right next to the Xavante but eating modern foods from the trading post, had 9 times more malocclusion and nearly 10 times more cavities than the Xavante. Here's what Niswander had to say:

> Severe abrasion was not apparent among the Bakairi, and the dental arches did not appear as broad and massive as in the Xavantes. Dental caries and malocclusion were strikingly more prevalent; and, although not recorded systematically, the Bakairi also showed considerably more periodontal disease. If it can be assumed that the Bakairi once enjoyed a freedom from dental disease and malocclusion equal to that now exhibited by the Xavantes, the available data suggest that the changes in occlusal patterns as well as caries and periodontal disease have been too rapid to be accounted for by an hypothesis involving relaxed [genetic] selection.

The Masai of Kenya

The Masai are traditionally a pastoral people who live almost exclusively from their cattle. In 1945, and again in 1952, Dr. J. Schwartz examined the teeth of 408 and 273 Masai, respectively (#1 free full text; #2 ref). In the first study, he found that 8 percent of Masai

showed some form of malocclusion, while in the second study, only 0.4 percent of Masai were maloccluded. Although we don't know what his precise criteria were for diagnosing malocclusion, these are still very low numbers.

In both studies, 4 percent of Masai had cavities. Between the two studies, Schwartz found 67 cavities in 21,792 teeth, or 0.3 percent of teeth affected. This is almost exactly what Dr. Weston Price found when he visited them in 1935. From *Nutrition and Physical Degeneration*, page 138:

> In the Masai tribe, a study of 2,516 teeth in eighty-eight individuals distributed through several widely separated manyatas showed only four individuals with caries. These had a total of ten carious teeth, or only 0.4 per cent of the teeth attacked by tooth decay.

Dr. Schwartz describes their diet:

> The principal food of the Masai is milk, meat and blood, the latter obtained by bleeding their cattle... The Masai have ample means with which to get maize meal and fresh vegetables but these foodstuffs are known only to those who work in town. It is impossible to induce a Masai to plant their own maize or vegetables near their huts.

This is essentially the same description Price gave during his visit. The Masai were not hunter-gatherers, but their traditional lifestyle was close enough to allow good occlusion. Here's why I think the Masai had good occlusion:

- A nutrient-dense diet rich in protein and fat-soluble vitamins from pastured dairy.
- On-demand breast feeding for two or more years.
- No bottle feeding or modern pacifiers.

The one factor they lack is tough food. Their diet, composed mainly of milk and blood, is predominantly liquid. Although I think food toughness is a factor, this shows that good occlusion is not entirely dependent on tough food.

Sadly, the lifestyle and occlusion of the Masai has changed in the intervening decades. A paper from 1992 described their modern diet:

> The main articles of diet were white maize, [presumably heavily sweetened] tea, milk, [white] rice, and beans. Traditional items were rarely eaten... Milk... was not mentioned by 30% of mothers.

A paper from 1993 described the occlusion of 235 young Masai attending rural and peri-urban schools. Nearly all showed some degree of malocclusion, with open bite alone affecting 18 percent.

Rural Caucasians in Kentucky

It's always difficult to find examples of Caucasian populations living traditional lifestyles, because most Caucasian populations adopted the industrial lifestyle long ago. That's why I was grateful to find a study by Dr. Robert S. Corruccini, published in 1981, titled "Occlusal Variation in a Rural Kentucky Community" (ref).

This study examined a group of isolated Caucasians living in the Mammoth Cave region of Kentucky, USA. Corruccini arrived during a time of transition between traditional and modern foodways. He describes the traditional lifestyle as follows:

> Much of the traditional way of life of these people (all white) has been maintained, but two major changes have been the movement of industry and mechanized farming into the area in the last 25 years. Traditionally, tobacco (the only cash crop), gardens, and orchards were grown by each family. Apples, pears, cherries, plums, peaches, potatoes, corn, green beans, peas, squash, peppers, cucumbers, and onions were grown for consumption, and fruits and nuts, grapes, and teas were gathered by individuals. In the diet of these people, dried pork and fried [presumably in lard], thick-crust cornbread (which were important winter staples) provided consistently stressful chewing. Hunting is still very common in the area.

Although it isn't mentioned in the paper, this group, like nearly all traditionally-living populations, probably did not waste the organs or bones of the animals it ate. Altogether, it appears to be an excellent and varied diet, based on whole foods, and containing all the elements necessary for good occlusion and overall health.

The older generation of this population has the best occlusion of any Caucasian population I've ever seen, rivaling some hunter-gatherer groups. This shows that Caucasians are not genetically doomed to malocclusion. The younger generation, living on more modern foods, shows very poor occlusion, among the worst I've seen. They also show narrowed arches, a characteristic feature of deteriorating occlusion. One generation is all it takes. Corruccini found that a higher malocclusion score was associated with softer, more industrial foods.

Here are the reasons I believe this group of Caucasians in Kentucky had good occlusion:

- A nutrient-rich, whole foods diet, presumably including organs.
- Prolonged breast feeding.
- No bottle-feeding or modern pacifiers.
- Tough foods on a regular basis.

Common Ground

I hope you can see that populations with excellent teeth do certain things in common, and that straying from those principles puts the next generation at a high risk of malocclusion. Malocclusion is a serious problem that has major implications for health, well-being and finances. In the next post, I'll give a simplified summary of everything I've covered in this series. Then it's back to our regularly scheduled programming.

Posted by Stephan Guyenet at 4:00 PM 29 comments

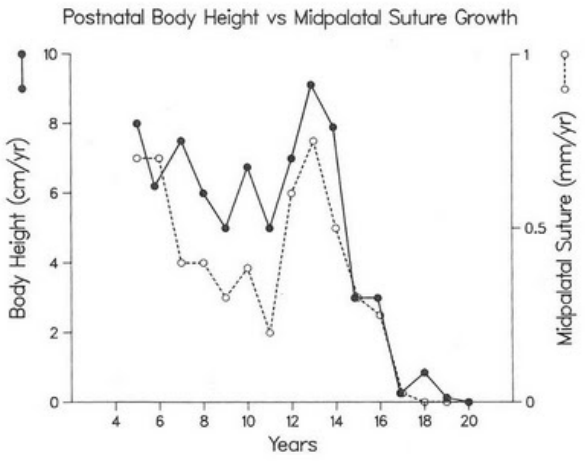
Labels: dental health, diet, diseases of civilization, Masai, native diet

Tuesday, November 24, 2009

Malocclusion: Disease of Civilization, Part VII

Jaw Development During Adolescence

Beginning at about age 11, the skull undergoes a growth spurt. This corresponds roughly with the growth spurt in the rest of the body, with the precise timing depending on gender and other factors. Growth continues until about age 17, when the last skull sutures cease growing and slowly fuse. One of these sutures runs along the center of the maxillary arch (the arch in the upper jaw), and contributes to the widening of the upper arch*:



This growth process involves MGP and osteocalcin, both vitamin K-dependent proteins. At the end of adolescence, the jaws have reached their final size and shape, and should be large enough to accommodate all teeth without crowding. This includes the third molars, or wisdom teeth, which will erupt shortly after this period.

Reduced Food Toughness Correlates with Malocclusion in Humans

When Dr. Robert Corruccini published his seminal paper in 1984 documenting rapid changes in occlusion in cultures around the world adopting modern foodways and lifestyles (see this post), he presented the theory that occlusion is influenced by chewing stress. In other words, the jaws require good exercise on a regular basis during growth to develop normal-sized bones and muscles. Although Dr. Corruccini wasn't the first to come up with the idea, he has probably done more than anyone else to advance it over the years.

Dr. Corruccini's paper is based on years of research in transitioning cultures, much of which he conducted personally. In 1981, he published a study of a rural Kentucky community in the process of adopting the modern diet and lifestyle. Their traditional diet was predominantly dried pork, cornbread fried in lard, game meat and home-grown fruit, vegetables and nuts. The older generation, raised on traditional foods, had much better occlusion than the younger generation, which had transitioned to softer and less nutritious modern foods. Dr. Corruccini found that food toughness correlated with proper occlusion in this population.

In another study published in 1985, Dr. Corruccini studied rural and urban Bengali youths. After collecting a variety of diet and socioeconomic information, he found that food toughness was the single best predictor of occlusion. Individuals who ate the toughest food had the best teeth. The second strongest association was a history of thumb sucking, which was associated with a higher prevalence of malocclusion**. Interestingly, twice as many urban youths had a history of thumb sucking as rural youths.

Not only do hunter-gatherers eat tough foods on a regular basis, they also often use their jaws as tools. For example, the anthropologist and arctic explorer Vilhjalmur Stefansson described how the Inuit chewed their leather boots and jackets nearly every day to soften them or prepare them for sewing. This is reflected in the extreme tooth wear of traditional Inuit and other hunter-gatherers.

Soft Food Causes Malocclusion in Animals

Now we have a bunch of associations that may or may not represent a cause-effect relationship. However, Dr. Corruccini and others have shown in a variety of animal models that soft food can produce malocclusion, independent of nutrition.

The first study was conducted in 1951. Investigators fed rats typical dry chow pellets, or the same pellets that had been crushed and softened in water. Rats fed the softened food during growth developed narrow arches and small mandibles (lower jaws) relative to rats fed dry pellets.

Other research groups have since repeated the findings in rodents, pigs and several species of primates (squirrel monkeys, baboons, and macaques). Animals typically developed narrow arches, a central aspect of malocclusion in modern humans. Some of the primates fed soft foods showed other malocclusions highly reminiscent of modern humans as well, such as crowded incisors and impacted third molars. These traits are exceptionally rare in wild primates.

One criticism of these studies is that they used extremely soft foods that are softer than the typical modern diet. This is how science works: you go for the extreme effects first. Then, if you see something, you refine your experiments. One of the most refined experiments I've seen so far was published by Dr. Daniel E. Leiberman of Harvard's anthropology department. They used the rock hyrax, an animal with a skull that bears some similarities to the human skull***.

Instead of feeding the animals hard food vs. mush, they fed them raw and dried food vs. cooked. This is closer to the situation in humans, where food is soft but still has some consistency. Hyrax fed cooked food showed a mild jaw underdevelopment reminiscent of

modern humans. The underdeveloped areas were precisely those that received less strain during chewing.

Implications and Practical Considerations

Besides the direct implications for the developing jaws and face, I think this also suggests that physical stress may influence the development of other parts of the skeleton. Hunter-gatherers generally have thicker bones, larger joints, and more consistently well-developed shoulders and hips than modern humans. Physical stress is part of the human evolutionary template, and is probably critical for the normal development of the skeleton.

I think it's likely that food consistency influences occlusion in humans. In my opinion, it's a good idea to regularly include tough foods in a child's diet as soon as she is able to chew them properly and safely. This probably means waiting at least until the deciduous (baby) molars have erupted fully. Jerky, raw vegetables and fruit, tough cuts of meat, nuts, dry sausages, dried fruit, chicken bones and roasted corn are a few things that should stress the muscles and bones of the jaws and face enough to encourage normal development.

* These data represent many years of measurements collected by Dr. Arne Bjork, who used metallic implants in the maxilla to make precise measurements of arch growth over time in Danish youths. The graph is reproduced from the book *A Synopsis of Craniofacial Growth*, by Dr. Don M. Ranly. Data come from Dr. Bjork's findings published in the book *Postnatal Growth and Development of the Maxillary Complex*. You can see some of Dr. Bjork's data in the paper "Sutural Growth of the Upper Face Studied by the Implant Method" (free full text).

** I don't know if this was statistically significant at p less than 0.05. Dr. Corruccini uses a cutoff point of p less than 0.01 throughout the paper. He's a tough guy when it comes to statistics!

*** Retrognathic.

Posted by Stephan Guyenet at 8:00 PM 24 comments

Labels: dental health, diet, diseases of civilization, exercise, Inuit

Tuesday, November 17, 2009

Malocclusion: Disease of Civilization, Part VI

Early Postnatal Face and Jaw Development

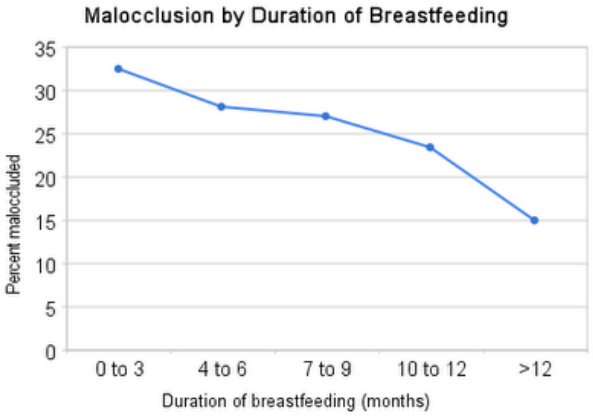
The face and jaws change more from birth to age four than at any other period of development after birth. At birth, infants have no teeth and their skull bones have not yet fused, allowing rapid growth. This period has a strong influence on the development of the jaws and face. The majority of malocclusions are established by the end this stage of development. Birth is the point at which the infant begins using its jaws and facial musculature in earnest.

The development of the jaws and face is very plastic, particularly during this period. Genes do not determine the absolute size or shape of any body structure. Genes carry the blueprint for all structures, and influence their size and shape, but structures develop relative to one another and in response to the forces applied to them during growth. This is how orthodontists can change tooth alignment and occlusion by applying force to the teeth and jaws.

Influences on Early Postnatal Face and Jaw Development

In 1987, Miriam H. Labbok and colleagues published a subset of the results of the National Health Interview survey (now called NHANES) in the *American Journal of Preventive Medicine*. Their article was provocatively titled "Does Breast-feeding Protect Against Malocclusion"? The study examined the occlusion of nearly 10,000 children, and interviewed the parents to determine the duration of breast

feeding. Here's what they found:

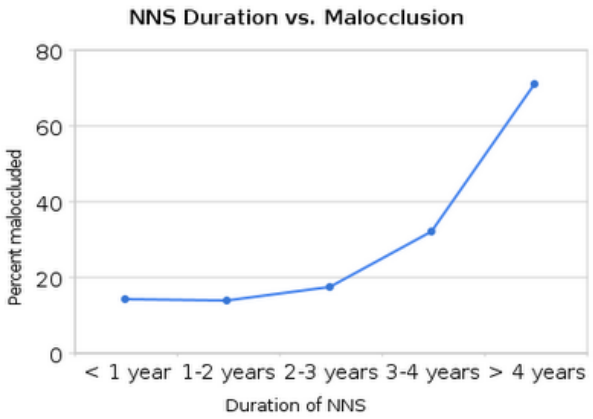


The longer the infants were breastfed, the lower their likelihood of major malocclusion. The longest category was "greater than 12 months", in which the prevalence of malocclusion was less than half that of infants who were breastfed for three months or less. Hunter-gatherers and other non-industrial populations typically breastfeed for 2-4 years, but this is rare in affluent nations. Only two percent of the mothers in this study breastfed for longer than one year.

The prevalence and duration of breastfeeding have increased dramatically in the US since the 1970s, with the prevalence doubling between 1970 and 1980 (NHANES). The prevalence of malocclusion in the US has decreased somewhat in the last half-century, but is still very common (NHANES).

Several, but not all studies have found that infants who were breastfed have a smaller risk of malocclusion later in life (1, 2, 3). However, what has been more consistent is the association between non-nutritive sucking and malocclusion. Non-nutritive sucking (NNS) is when a child sucks on an object without getting calories out of it. This includes pacifier sucking, which is strongly associated with malocclusion*, and finger sucking, which is also associated to a lesser degree.

The longer a child engages in NNS, the higher his or her risk of malocclusion. The following graph is based on data from a study of nearly 700 children in Iowa (free full text). It charts the prevalence of three types of malocclusion (anterior open bite, posterior crossbite and excessive overjet) broken down by the duration of the NNS habit:



As you can see, there's a massive association. Children who sucked pacifiers or their fingers for more than four years had a 71 percent chance of having one of these three specific types of malocclusion, compared with 14 percent of children who sucked for less than a year. The association between NNS and malocclusion appeared after two years of NNS. Other studies have come to similar conclusions, including a 2006 literature review (1, 2, 3).

Bottle feeding, as opposed to direct breast feeding, is also associated with a higher risk of malocclusion (1, 2). One of the most important functions of breast feeding may be to displace NNS and bottle feeding. Hunter-gatherers and non-industrial cultures breast fed their children on demand, typically for 2-4 years, in addition to giving them solid food.

In my opinion, it's likely that NNS beyond two years of age, and bottle feeding to a lesser extent, cause

a large proportion of the malocclusions in modern societies. Pacifier use seems to be particularly problematic, and finger sucking to a lesser degree.

How Do Breastfeeding, Bottle Feeding and NNS Affect Occlusion?

Since jaw development is influenced by the forces applied to them, it makes sense that the type of feeding during this period could have a major impact on occlusion. Children who have a prolonged pacifier habit are at high risk for open bite, a type of malocclusion in which the incisors don't come together when the jaws are closed. You can see a picture here. The teeth and jaws mold to the shape of the pacifier over time. This is because the growth patterns of bones respond to the forces that are applied to them. I suspect this is true for other parts of the skeleton as well.

Any force applied to the jaws that does not approximate the natural forces of breastfeeding or chewing and swallowing food, will put a child at risk of malocclusion during this period of his or her life. This includes NNS and bottle feeding. Pacifier sucking, finger sucking and bottle feeding promote patterns of muscular activity that result in weak jaw muscles and abnormal development of bony structures, whereas breastfeeding, chewing and swallowing strengthen jaw muscles and promote normal development (review article). This makes sense, because our species evolved in an environment where the breast and solid foods were the predominant objects that entered a child's mouth.

What Can We do About it?

In an ideal world (ideal for occlusion), mothers would breast feed on demand for 2-4 years, and introduce solid food about halfway through the first year, as our species has done since the beginning of time. For better or worse, we live in a different world than our ancestors, so this strategy will be difficult or impossible for many people. Are there any alternatives?

Parents like bottle feeding because it's convenient. Milk can be prepared in advance, the mother doesn't have to be present, feeding takes less time, and the parents can see exactly how much milk the child has consumed. One alternative to bottle feeding that's just as convenient is cup feeding. Cup feeding, as opposed to bottle feeding, promotes natural swallowing motions, which are important for correct development. The only study I found that examined the effect of cup feeding on occlusion found that cup-fed children developed fewer malocclusion and breathing problems than bottle-fed children.

Cup feeding has a long history of use. Several studies have found it to be safe and effective. It appears to be a good alternative to bottle feeding, that should not require any more time or effort.

What about pacifiers? Parents know that pacifiers make babies easier to manage, so they will be reluctant to give them up. Certain pacifier designs may be more detrimental than others. I came across the abstract of a study evaluating an "orthodontic pacifier" called the Dentistar, made by Novatex. The frequency of malocclusion was much lower in children who did not use a pacifier or used the Dentistar, than in those who used a more conventional pacifier. This study was funded by Novatex, but was conducted at Heinrich Heine University in Dusseldorf, Germany**. The pacifier has a spoon-like shape that allows normal tongue movement and exerts minimal pressure on the incisors. There may be other brands with a similar design.

The ideal is to avoid bottle feeding and pacifiers entirely. However, cup feeding and orthodontic pacifiers appear to be acceptable alternatives that minimize the risk of malocclusion during this critical developmental window.

* Particularly anterior open bite and posterior crossbite.

** I have no connection whatsoever to this company. I think the results of the trial are probably valid, but should be replicated.

Posted by Stephan Guyenet at 8:00 PM 64 comments

Labels: dental health, diseases of civilization, exercise

Tuesday, November 10, 2009

Malocclusion: Disease of Civilization, Part V

Prenatal Development of the Face and Jaws

The structures of the face and jaws take shape during the first trimester of pregnancy. The 5th to 11th weeks of pregnancy are particularly crucial for occlusion, because this is when the jaws, nasal septum and other cranial structures form. The nasal septum is the piece of cartilage that forms the structure of the nose and separates the two air passages as they enter the nostrils.

Maternal Nutritional Status Affects Fetal Development

Abnormal nutrient status can lead to several types of birth defects. Vitamin A is an essential signaling molecule during development. Both deficiency and excess can cause birth defects, with the effects predominantly targeting the cranium and nervous system, respectively. Folic acid deficiency causes birth defects of the brain and spine. Other nutrients such as vitamin B12 may influence the risk of birth defects as well*.

The Role of Vitamin K

As early as the 1970s, physicians began noting characteristic developmental abnormalities in infants whose mothers took the blood-thinning drug warfarin (coumadin) during the first trimester of pregnancy. These infants showed an underdevelopment of the nasal septum, the maxilla (upper jaw), small or absent sinuses, and a characteristic "dished" face. This eventually resulted in narrow dental arches, severe malocclusion and tooth crowding**. The whole spectrum was called Binder's syndrome, or warfarin embryopathy.

Warfarin works by inhibiting vitamin K recycling, thus depleting a nutrient necessary for normal blood clotting. It's now clear that Binder's syndrome can result from anything that interferes with vitamin K status during the first trimester of pregnancy. This includes warfarin, certain anti-epilepsy drugs, certain antibiotics, genetic mutations that interfere with vitamin K status, and celiac disease (intestinal damage due to gluten).

Why is vitamin K important for the development of the jaws and face of the fetus? Vitamin K is required to activate a protein called matrix gla protein (MGP), which prevents unwanted calcification of the nasal septum in the developing fetus (among other things). If this protein isn't activated by vitamin K during the critical developmental window, calcium deposits form in the nasal septum, stunting its growth and also stunting the growth of the maxilla and sinuses. Low activity of MGP appears to be largely responsible for Binder's syndrome, since the syndrome can be caused by genetic mutations in MGP in humans. Small or absent sinuses are common in the general population.

One of the interesting things about MGP is its apparent preference for vitamin K2 over vitamin K1. Vitamin K1 is found predominantly in green vegetables, and is sufficient to activate blood clotting factors and probably some other vitamin K-dependent proteins. "Vitamin K2" refers to a collection of molecules known as menaquinones. These are denoted as "MK", followed by a number indicating the length of the side chain attached to the quinone ring.

Biologically important menaquinones are MK-4 through MK-12 or so. MK-4 is the form that animals synthesize from vitamin K1 for their own use. Certain organs (brain, pancreas, salivary gland, arteries) preferentially accumulate K2 MK-4, and certain cellular processes are also selective for K2 MK-4 (MGP activation, PKA-dependent transcriptional effects). Vitamin K2 MK-4 is found almost exclusively in animal foods, particularly pastured butter, organs and eggs. It is always found in foods designed to nourish growing animals, such as eggs and milk.

Humans have the ability to convert K1 to K2 when K1 is ingested in artificially large amounts. However, due to the limited absorption of normal dietary sources of K1 and the unknown conversion efficiency, it's unclear how much green vegetables contribute to K2 status. Serum vitamin K1 reaches a plateau at about 200 micrograms per day of dietary K1 intake, the equivalent of 1/4 cup of cooked spinach (see figure 1 of this paper). Still, I think eating green vegetables regularly is a good idea, and may contribute to K2 status. Other menaquinones such as MK-7 (found in natto) may contribute to K2 status as well, but this question has not been resolved.

Severe vitamin K deficiency clearly impacts occlusion. Could more subtle deficiency lead

to a less pronounced form of the same developmental syndrome? Here are a few facts about vitamin K relevant to this question:

- In industrial societies, newborns are typically vitamin K deficient. This is reflected by the fact that in the US, nearly all newborns are given vitamin K1 at birth to prevent potentially fatal hemorrhage. In Japan, infants are given vitamin K2 MK-4, which is equally effective at preventing hemmorhage.
- Fetuses generally have low vitamin K status, as measured by the activity of their clotting factors.
- The human placenta transports vitamin K across the placental barrier and accumulates it. This transport mechanism is highly selective for vitamin K2 MK-4 over K1.
- The concentration of K1 in maternal blood is much higher than its concentration in umbilical cord blood, whereas the concentration of K2 in maternal blood is similar to the concentration in cord blood. Vitamin K2 MK-7 is undetectable in cord blood, even when supplemented, suggesting that MK-7 is not an adequate substitute for MK-4 during pregnancy.
- In rat experiments, arterial calcification due to warfarin was inhibited by vitamin K2 MK-4, but not vitamin K1. This is probably due to K2's ability to activate MGP, the same protein required for the normal development of the human face and jaws.
- The human mammary gland appears to be the most capable organ at converting vitamin K1 to K2 MK-4.

Together, this suggests that in industrial societies, fetuses and infants are vitamin K deficient, to the point of being susceptible to fatal hemorrhage. It also suggests that vitamin K2 MK-4 plays a critical role in fetal and early postnatal development. Could subclinical vitamin K2 deficiency be contributing to the high prevalence of malocclusion in modern societies?

An Ounce of Prevention

Vitamin A, folic acid, vitamin D and vitamin K2 are all nutrients with a long turnover time. Body stores of these nutrients depend on long-term intake. Thus, the nutritional status of the fetus during the first trimester reflects what the mother has been eating for several months *before conception*.

Dr. Weston Price noted that a number of the traditional societies he visited prepared women of childbearing age for healthy pregnancies by giving them special foods rich in fat-soluble vitamins. This allowed them to gestate and rear healthy, well-formed children. Nutrient-dense animal foods and green vegetables are a good idea before, during and after pregnancy.

* Liver is the richest source of vitamin A, folic acid and B12.

** Affected individuals may show class I, II, or III malocclusion.

Posted by Stephan Guyenet at 8:00 PM 30 comments

Labels: celiac, dental health, diet, diseases of civilization, fat-soluble vitamins

Wednesday, October 14, 2009

Malocclusion: Disease of Civilization, Part IV

There are three periods during the development of the face and jaws that are uniquely sensitive to environmental influences such as nutrition and muscle activity patterns.

1: Prenatal Period

The major structures of the human face and jaws develop during the first trimester of pregnancy. The

maxilla (upper jaw) takes form between the 7th and 10th week after conception. The mandible (lower jaw) begins two weeks earlier. The nasal septum, which is the piece of cartilage that forms the structure of the nose and divides the nostrils, appears at week seven and grows most rapidly from weeks 8 to 11. Any disturbance of this developmental window can have major consequences for later occlusion.

2: Early Postnatal Period

The largest postnatal increment in face and jaw growth occurs from birth until age 4. During this period, the deciduous (baby) teeth erupt, and the activity patterns of the jaw and tongue influence the size and shape of the maxilla and the mandible as they grow. The relationship of the jaws to one another is mostly determined during this period, although it can still change later in development.

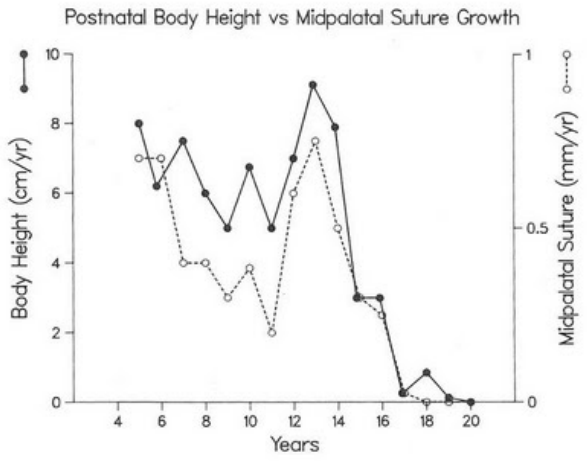
During this period, the dental arch widens from its center, called the midpalatal suture. This ensures that the jaws are the correct size and shape to eventually accept the permanent teeth without crowding them.

3: Adolescence

The third major developmental period occurs between ages 11 and 16, depending on the gender and individual, and happens roughly at the same time as the growth spurt in height. The dental arch continues to widen, reaching its final size and shape. Under ideal circumstances, at the end of this period the arch should be large enough to accommodate all teeth, including the third molars (wisdom teeth), without crowding. Narrow dental arches cause malocclusion and third molar crowding.

Growth of the Dental Arch Over Time

The following graph shows the widening of the dental arch over time*. The dotted line represents arch growth while the solid line represents growth in body height. You can see that arch development slows down after 6 years old, resumes around 11, and finally ends at about 18 years. This graph represents the average of many children, so not all children will see these changes at the age indicated. The numbers are in millimeters per year, but keep in mind that the difference between a narrow arch and a broad one is only a few millimeters.



In the next few posts, I'll describe the factors that I believe influence jaw and face structure during the three critical periods of development.

* These data represent many years of measurements collected by Dr. Arne Bjork, who used metallic implants in the maxilla to make precise measurements of arch growth over time in Danish youths. The graph is reproduced from the book *A Synopsis of Craniofacial Growth*, by Dr. Don M. Ranly. Data come from Dr. Bjork's findings published in the book *Postnatal Growth and Development of the Maxillary Complex*. You can see some of Dr. Bjork's data in the paper "Sutural Growth of the Upper Face Studied by the Implant Method" (free full text).

Posted by Stephan Guyenet at 8:00 PM 21 comments

Labels: dental health, diseases of civilization

Malocclusion: Disease of Civilization, Part III

Normal Human Occlusion

In 1967, a team of geneticists and anthropologists published an extensive study of a population of Brazilian hunter-gatherers called the Xavante (1). They made a large number of physical measurements, including of the skull and jaws. Of 146 Xavante examined, 95% had "ideal" occlusion, while the 5% with malocclusion had nothing more than mild crowding of the incisors (front teeth). The authors wrote:

> Characteristically, the Xavante adults exhibited broad dental arches, almost perfectly aligned teeth, end-to-end bite, and extensive dental attrition [tooth wear].

In the same paper, the author presents occlusion statistics for three other cultures. According to the papers he cites, in Japan, the prevalence of malocclusion was 59%, and in the US (Utah), it was 64%. He also mentions another native group living near the Xavante, part of the Bakairi tribe, living at a government post and presumably eating processed food. The prevalence of malocclusion was 45% in this group.

In 1998, Dr. Brian Palmer (DDS) published a paper describing some of the collections of historical skulls he had examined over the years (2):

> ...I reviewed an additional twenty prehistoric skulls, some dated at 70,000 years old and stored in the Anthropology Department at the University of Kansas. Those skulls also exhibited positive [good] occlusions, minimal decay, broad hard palates, and "U-shaped" arches.
>
> The final evaluations were of 370 skulls preserved at the Smithsonian Institution in Washington, D.C. The skulls were those of prehistoric North American plains Indians and more contemporary American skulls dating from the 1920s to 1940s. The prehistoric skulls exhibited the same features as mentioned above, whereas a significant destruction and collapse of the oral cavity were evident in the collection of the more recent skulls. Many of these more recent skulls revealed severe periodontal disease, malocclusions, missing teeth, and some dentures. This was not the case in the skulls from the prehistoric periods...

The arch is the part of the upper jaw inside the "U" formed by the teeth. Narrow dental arches are a characteristic feature of malocclusion-prone societies. The importance of arch development is something that I'll be coming back to repeatedly. Dr. Palmer's paper includes the following example of prehistoric (L) and modern (R) arches:

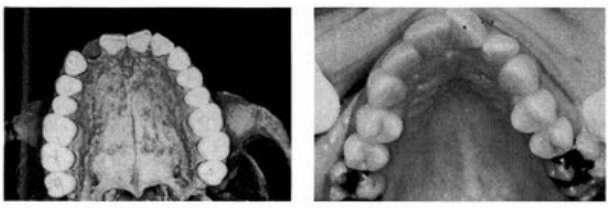


Figure 3. Compares a normal palate and "U-shaped" uncrowded arch of a prehistoric skull to a high palate and "V-shaped" crowded arch of a modern individual.

Dr. Palmer used an extreme example of a modern arch to illustrate his point, however, arches of this width are not uncommon today. Milder forms of this narrowing affect the majority of the population in industrial nations.

In 1962, Dr. D.H. Goose published a study of 403 British skulls from four historical periods: Romano-British, Saxon, medieval and modern (3). He found that the arches of modern skulls were less broad than at any previous time in history. This followed an earlier study showing that modern British skulls had more frequent malocclusion than historical skulls (4). Goose stated that:

> Although irregularities of the teeth can occur in earlier populations, for example in the Saxon skulls studied by Smyth (1934), the narrowing of the palate seems to have occurred in too short a period to be an evolutionary change. Hooton (1946) thinks it is a speeding up of an already long standing change under conditions of city life.

Dr. Robert Corruccini published several papers documenting narrowed arches in one generation of dietary change, or in genetically similar populations living rural or urban lifestyles (reviewed in reference #5). One was a study of Caucasians in Kentucky, in which a change from a traditional subsistence diet to modern industrial food habits accompanied a marked narrowing of arches and increase in malocclusion in one generation. Another study examined older and younger generations of Pima Native Americans, which again showed a reduction in arch width in one generation. A third compared rural and urban Indians living in the vicinity of Chandigarh, showing marked differences in arch breadth and the prevalence of malocclusion between the two genetically similar populations. Corruccini states:

> In Chandigarh, processed food predominates, while in the country coarse millet and locally grown vegetables are staples. Raw sugar cane is widely chewed for enjoyment rurally [interestingly, the rural group had the lowest incidence of tooth decay], and in the country dental care is lacking, being replaced by chewing on acacia boughs which clean the teeth and are considered medicinal.

Dr. Weston Price came to the same conclusion examining prehistoric skulls from South America, Australia and New Zealand, as well as their living counterparts throughout the world that had adhered to traditional cultures and foodways. From *Nutrition and Physical Degeneration*:

> In a study of several hundred skulls taken from the burial mounds of southern Florida, the incidence of tooth decay was so low as to constitute an immunity of apparently one hundred per cent, since in several hundred skulls not a single tooth was found to have been attacked by tooth decay. Dental arch deformity and the typical change in facial form due to an inadequate nutrition were also completely absent, all dental arches having a form and interdental relationship [occlusion] such as to bring them into the classification of normal.

Price found that the modern descendants of this culture, eating processed food, suffered from malocclusion and narrow arches, while another group from the same culture living traditionally did not. Here's one of Dr. Price's images from *Nutrition and Physical Degeneration* (p. 212). This skull is from a prehistoric New Zealand Maori hunter-gatherer:

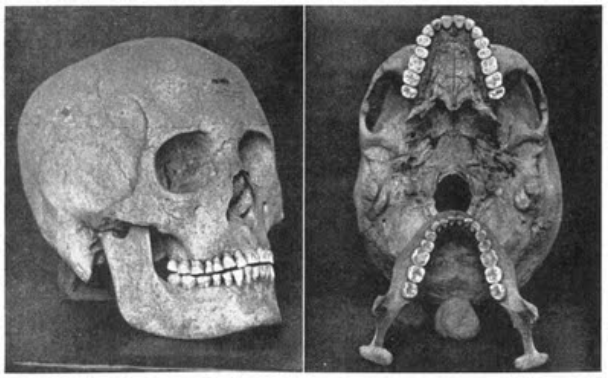


FIG. 73. The large collections of skulls of the ancient Maori of New Zealand attest to their superb physical development and to the excellence of their dental arches.

Note the well-formed third molars (wisdom teeth) in both of the prehistoric skulls I've posted. These people had ample room for them in their broad arches. Third molar crowding is a mild form of modern face/jaw deformity, and affects the majority of modern populations. It's the reason people have their wisdom teeth removed. Urban Nigerians in Lagos have 10 times more third molar crowding than rural Nigerians in the same state (10.7% of molars vs. 1.1%, reference #6).

Straight teeth and good occlusion are the human evolutionary norm. They're also accompanied by a wide dental arch and ample room for third molars in many traditionally-living cultures. The combination of narrow arches, malocclusion, third molar crowding, small or absent sinuses, and a characteristic underdevelopment of the middle third of the face, are part of a developmental syndrome that predominantly afflicts industrially living cultures.

(1) Am. J. Hum. Genet. 19(4):543. 1967. (free full text)
(2) J. Hum. Lact. 14(2):93. 1998
(3) Arch. Oral Biol. 7:343. 1962
(4) Brash, J.C.: The Aetiology of Irregularity and Malocclusion of the Teeth. Dental Board of the United Kingdom, London, 1929.
(5) Am J. Orthod. 86(5):419
(6) Odonto-Stomatologie Tropicale. 90:25. (free full text)

Posted by Stephan Guyenet at 2:40 PM 16 comments

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Labels: archaeology, dental health, diseases of civilization

Saturday, October 3, 2009

Malocclusion: Disease of Civilization, Part II

The Nature of the Problem

In 1973, the US Centers for Disease Control and Prevention (CDC) published the results of a National Health Survey in which it examined the dental health of American youths nationwide. The following description was published in a special issue of the journal Pediatric Dentistry (1):

> The 1973 National Health Survey reported 75% of children, ages 6 to 11 years, and 89% of youths, ages 12 to 17 years, have some degree of occlusal disharmony [malocclusion]; 8.7% of children and 13% of youth had what was considered a severe handicapping malocclusion for which treatment was highly desirable and 5.5% of children and 16% of youth had a severe handicapping malocclusion that required mandatory treatment.

89% of youths had some degree of malocclusion, and 29% had a severe handicapping malocclusion for which treatment was either highly desirable or mandatory. Fortunately, many of these received orthodontics so the malocclusion didn't persist into adulthood.

This is consistent with another survey conducted in 1977, in which 38% of American youths showed definite or severe malocclusion. 46% had occlusion that the authors deemed "ideal or acceptable" (2).

The trend continues. The CDC National Health and Nutrition Examination Survey III (NHANES III) found in 1988-1991 that approximately three fourths of Americans age 12 to 50 years had some degree of malocclusion (3).

The same holds true for Caucasian-Americans, African-Americans and Native Americans in the US, as well as other industrial nations around the world. Typically, only 1/3 to 1/2 of the population shows good (but not necessarily perfect) occlusion (4- 8).

In the next post, I'll review some of the data from non-industrial and transitioning populations.

Malocclusion: Disease of Civilization

1. Pediatr. Dent. 17(6):1-6. 1995-1996
2. USPHS Vital and Health Statistics Ser. 11, no 162. 1977
3. J. Dent. Res. Special issue. 75:706. 1996. Pubmed link.
4. *The Evaluation of Canadian Dental Health*. 1959. Describes Canadian occlusion.
5. *The Effects of Inbreeding on Japanese Children*. 1965. Contains data on Japanese occlusion.
6. J. Dent. Res. 35:115. 1956. Contains data on both industrial and non-industrial cultures (Pukapuka, Fiji, New Guinea, U.S.A. and New Zealand).
7. J. Dent. Res. 44:947. 1965 (free full text). Contains data on Caucasian-Americans and African-Americans living in several U.S. regions, as well as data from two regions of Germany. Only includes data on Angle classifications, not other types of malocclusion such as crossbite and open bite (i.e., the data underestimate the total prevalence of malocclusion).
8. J. Dent. Res. 47:302. 1968 (free full text). Contains data on Chippewa Native Americans in the U.S., whose occlusion was particularly bad, especially when compared to previous generations.

Posted by Stephan Guyenet at 11:44 AM 13 comments

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Labels: dental health, diseases of civilization

Tuesday, September 29, 2009

Malocclusion: Disease of Civilization

In his epic work *Nutrition and Physical Degeneration*, Dr. Weston Price documented the abnormal dental development and susceptibility to tooth decay that accompanied the adoption of modern foods in a number of different cultures throughout the world. Although he quantified changes in cavity prevalence (sometimes finding increases as large as 1,000-fold), all we have are Price's anecdotes describing the crooked teeth, narrow arches and "dished" faces these cultures developed as they modernized.

Price published the first edition of his book in 1939. Fortunately, *Nutrition and Physical Degeneration* wasn't the last word on the matter. Anthropologists and archaeologists have been extending Price's findings throughout the 20th century. My favorite is Dr. Robert S. Corruccini, currently a professor of anthropology at Southern Illinois University. He published a landmark paper in 1984 titled "An Epidemiologic Transition in Dental Occlusion in World Populations" that will be our starting point for a discussion of how diet and lifestyle factors affect the development of the teeth, skull and jaw (Am J. Orthod. 86(5):419)*.

First, some background. The word **occlusion** refers to the manner in which the top and bottom sets of teeth come together, determined in part by the alignment between the upper jaw (maxilla) and lower jaw (mandible). There are three general categories:

- **Class I occlusion**: considered "ideal". The bottom incisors (front teeth) fit just behind the top incisors.
- **Class II occlusion**: "overbite." The bottom incisors are too far behind the top incisors. The mandible may appear small.
- **Class III occlusion**: "underbite." The bottom incisors are beyond the top incisors. The mandible protrudes.

Malocclusion means the teeth do not come together in a way that's considered ideal. The term "class I malocclusion" is sometimes used to describe crowded incisors when the jaws are aligning properly.

Over the course of the next several posts, I'll give an overview of the extensive literature showing that hunter-gatherers past and present have excellent occlusion, subsistence agriculturalists generally have good occlusion, and the adoption of modern foodways directly causes the crooked teeth, narrow arches and/or crowded third molars (wisdom teeth) that affect the majority of people in industrialized nations. I believe this process also affects the development of the rest of the skull, including the face and sinuses.

In his 1984 paper, Dr. Corruccini reviewed data from a number of cultures whose occlusion has been studied in detail. Most of these cultures were observed by Dr. Corruccini personally. He compared two sets of cultures: those that adhere to a traditional style of life and those that have adopted industrial foodways. For several of the cultures he studied, he compared it to another that was genetically similar. For example, the older generation of Pima indians vs. the younger generation, and rural vs. urban Punjabis. He also included data from archaeological sites and nonhuman primates. Wild animals, including nonhuman primates, almost invariably show perfect occlusion.

The last graph in the paper is the most telling. He compiled all the occlusion data into a single number called the "treatment priority index" (TPI). This is a number that represents the overall need for orthodontic treatment. A TPI of 4 or greater indicates malocclusion (the cutoff point is subjective and depends somewhat on aesthetic considerations). Here's the graph:

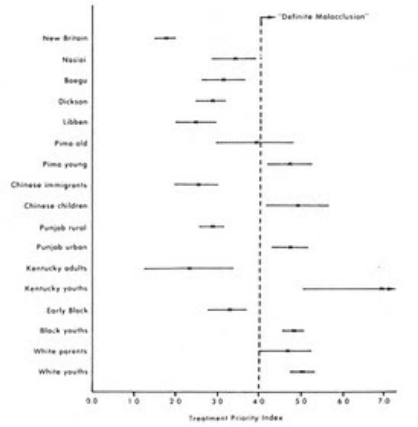


Fig. 6. Means and 95% confidence limits for the Treatment Priority Index. A *very* broad idea of consensual interpretation of this quantity can be gained by taking a value of 4.0 or more to generally indicate "malocclusion" and a score in excess of 7.0 to suggest "severe malocclusion." On the basis of these samples, for instance, some 3.5% of the persons in aboriginal populations would be "severely malocclucded" compared to 35% of the persons in industrialized populations.

Every single urban/industrial culture has an average TPI of greater than 4, while all the non-industrial or less industrial cultures have an average TPI below 4. This means that in industrial cultures, the average person requires orthodontic treatment to achieve good occlusion, whereas most people in more traditionally-living cultures naturally have good occlusion.

The best occlusion was in the New Britain sample, a precontact Melanesian hunter-gatherer group studied from archaeological remains. The next best occlusion was in the Libben and Dickson groups, who were early Native American agriculturalists. The Pima represent the older generation of Native Americans that was raised on a somewhat traditional agricultural diet, vs. the younger generation raised on processed reservation foods. The Chinese samples are immigrants and their descendants in Liverpool. The Punjabis represent urban vs. rural youths in Northern India. The Kentucky samples represent a traditionally-living Appalachian community, older generation vs. processed food-eating offspring. The "early black" and "black youths" samples represent older and younger generations of African-Americans in the Cleveland and St. Louis area. The "white parents/youths" sample represents different generations of American Caucasians.

The point is clear: there's something about industrialization that causes malocclusion. It's not genetic; it's a result of changes in diet and/or lifestyle. A "disease of civilization". I use that phrase loosely, because malocclusion isn't really a disease, and some cultures that qualify as civilizations retain traditional foodways and relatively good teeth. Nevertheless, it's a time-honored phrase that encompasses the wide array of health problems that occur when humans stray too far from their ecological niche. I'm going to let Dr. Corruccini wrap this post up for me:

> I assert that these results serve to modify two widespread generalizations: that imperfect occlusion is not necessarily abnormal, and that prevalence of malocclusion is genetically controlled so that preventive therapy in the strict sense is not possible. **Cross-cultural data dispel the notion that considerable occlusal variation [malocclusion] is inevitable or normal. Rather, it is an aberrancy of modern urbanized populations.** Furthermore, the transition from predominantly good to predominantly bad occlusion repeatedly occurs within one or two generations' time in these (and other) populations, weakening arguments that explain high malocclusion prevalence genetically.

* This paper is worth reading if you get the chance. It should have been a seminal paper in the field of preventive orthodontics, which could have largely replaced conventional orthodontics by now. Dr. Corruccini is the clearest thinker on this subject I've encountered so far.

Posted by Stephan Guyenet at 7:00 PM 33 comments

Labels: archaeology, dental health, diet, diseases of civilization, genetics, Pima

Monday, July 6, 2009

Unrefined vs. Refined Carbohydrates and Dental Cavities

There's a definite association between the consumption of refined carbohydrates and dental cavities. Dr. Weston Price pointed this out in a number of transitioning societies in his epic work *Nutrition and Physical Degeneration*. Many other anthropologists and dentists have observed the same thing.

I believe, based on a large body of anthropological and medical data, that it's not just an association-- sugar and flour cause cavities. But why? Is it that they lack micronutrients-- the explanation favored by Price-- or do they harm teeth by feeding the bacteria that participate in cavity formation? Or both?

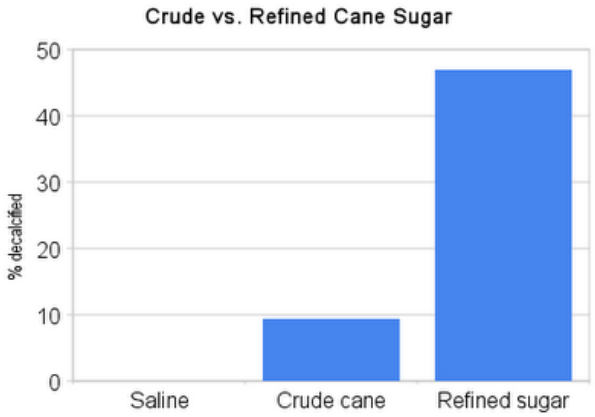
I recently found an interesting article when I was perusing an old copy of the Journal of Dental Research: "A Comparison of Crude and Refined Sugar and Cereals in Their Ability to Produce in vitro Decalcification of Teeth", published in 1937 by Dr. T. W. B. Osborn et al. (free full text). I love old papers. They're so free of preconceptions, and they ask big questions. The authors begin with the observation that the South African Bantu, similar to certain cultures Dr. Price visited, had a low prevalence of tooth decay when eating their native diet high in unrefined carbohydrate foods. However, their decay rate increased rapidly as modern foods such as white flour and refined sugar became available.

To test whether refined carbohydrates have a unique ability to cause tooth decay, the investigators took pieces of teeth that had been extracted for reasons other than decay (for example, crowding), and incubated them with a mixture of human saliva and several different carbohydrate foods:

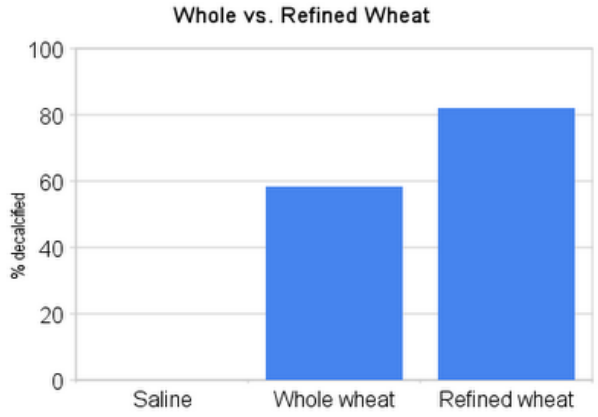
- crude cane juice
- refined cane sugar
- whole wheat flour
- white wheat flour
- whole corn meal
- refined corn meal

After incubating teeth in the solutions for 2-8 weeks at 37 C (human body temperature), they had trained dentists evaluate them for signs of decalcification. Decalcification is a loss of minerals that is part of the process of tooth decay. **Teeth, like bones, are mineralized primarily with calcium and phosphorus, and there is a dynamic equilibrium between minerals leaching out of the teeth and minerals entering them.**

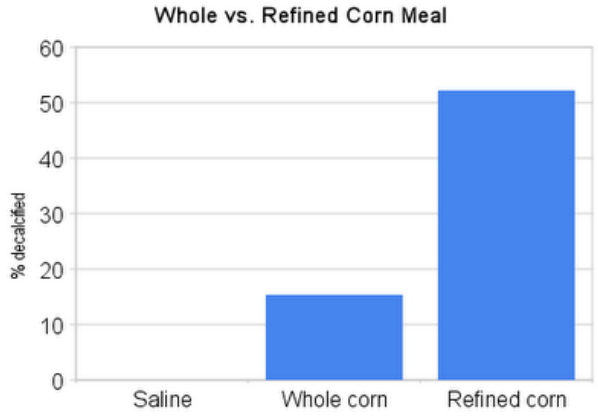
The researchers used teeth incubated in saline solution as the reference. The dentists were "blinded", meaning they didn't know which solution each tooth came from. This is a method of reducing bias. Here are some of the results. Cane juice vs. refined sugar:



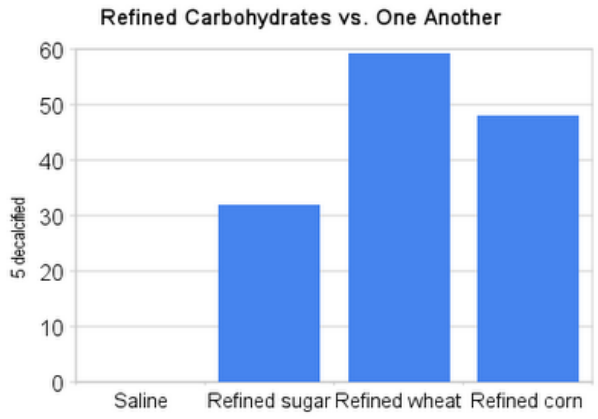
Unrefined cane juice was not very effective at causing decalcification, compared to refined sugar. This was a surprise to me. Here is the result for wheat:



Note that the scale is different on this graph. Wheat, and particularly refined wheat, is very good at decalcifying teeth *in vitro*. Corn:



Refined corn is much more effective at decalcifying teeth than whole meal corn. Next, the investigators performed an experiment where they compared the three types of refined carbohydrate to one another:



As one would predict from the graphs above, refined wheat is worse than refined corn, is worse than refined sugar. This is really at odds with conventional wisdom.

It's important to keep in mind that these results are not necessarily directly applicable to a living human being, who wouldn't let a mouthful of wheat porridge sit in his mouth for five weeks. But it does show that refining carbohydrates may increase their ability to cause cavities due to a direct effect on the teeth (rather than by affecting whole-body nutritional status, which they do as well).

The authors tested the acidity of the different solutions, and found no consistent differences between them (they were all at pH 4-5 within 24 hours), so acid production by bacteria didn't account for the results. They speculated that the mineral content of the unrefined carbohydrates may have prevented the bacterial acids from leaching minerals out of the teeth. Fortunately for us, they went on to test that speculation in a series of further investigations.

In another paper, Dr. T. W. B. Osborn and his group showed that they could greatly curb the decalcification process by adding organic calcium and phosphorus salts to the solution. This again points to a dynamic equilibrium, where minerals are constantly leaving and entering the tooth structure. The amounts of calcium and phosphorus required to inhibit calcification were similar to the amounts found in unrefined cane sugar, wheat and corn. This suggests the straightforward explanation that refined sugar and grains cause decay at least in part because most of the minerals are removed during the refining process.

However, we're still left with the puzzling fact that wheat and corn flour decalcify teeth *in vitro* more effectively than cane juice. I suspect that has to do with the phytic acid content of the grains, which binds the minerals and makes them partially unavailable to diffusion into the teeth. Cane juice contains minerals, but no phytic acid, so it may have a higher mineral availability. This explanation may not be able to account for the fact that refined sugar was also less effective at decalcifying teeth than refined wheat and corn flour. Perhaps the residual phytic acid in the refined grains actually drew minerals out of the teeth?

No, I'm not saying you can eat sugar with impunity if it's unrefined. There isn't a lot of research on the effects of refined vs. unrefined sugar, but I suspect too much sugar in any form isn't good. But this does suggest that refined carbohydrates may be particularly effective at promoting cavities, due to a direct demineralizing effect on teeth subsequent to bacterial acid production. It also supports Dr. Price's contention that a food's micronutrient content is the primary determinant of its effect on dental health.

Reversing Tooth Decay
Preventing Tooth Decay
Dental Anecdotes

Posted by Stephan Guyenet at 10:00 PM 87 comments

Labels: dental health, diet, disease

Wednesday, June 17, 2009

A Little Tidbit

I'm gearing up for a new series of posts based on some fascinating reading I've been doing lately. I'm not going to spill the beans, but I will give you a little hint, from a paper written by Dr. Robert S. Corruccini, professor of anthropology at Southern Illinois university. I just came across this quote and it blew me away. It's so full of wisdom I can't even believe I just read it. The term "occlusion" refers to the way the upper and lower teeth come together, as in overbite or underbite.

> Similar to heart disease and diabetes which are "diseases of civilization" or "Western diseases" (Trowell and Burkitt, 1981) that have attained high prevalence in urban society because of environmental factors rather than "genetic deterioration," an epidemiological transition (Omran, 1971) in occlusal health accompanies urbanization.
>
> Western society has completely crossed this transition and now exists in a state of industrially buffered environmental homogeneity. The relatively constant environment both raises genetic variance estimates (since environmental variance is lessened) and renders epidemiological surveys largely meaningless because etiological factors are largely uniform. Nevertheless most occlusal epidemiology and heritability surveys are conducted in this population rather than in developing countries currently traversing the epidemiological transition.

In other words, the reason observational studies in affluent nations haven't been able to get to the bottom of dental/orthodontic problems and chronic disease is that everyone in their study population is doing the same thing! There isn't enough variability in the diets and lifestyles of modern populations to be able to determine what's causing the problem. So we study the genetics of problems that are not genetic in origin, and overestimate genetic contributions because we're studying populations whose diet and lifestyle are homogeneous. It's a wild goose chase.

That's why you have to study modernizing populations that are transitioning from good to poor health, which is exactly what Dr. Weston Price and many others have done. Only then can you see the true, non-genetic, nature of the problem.

Posted by Stephan Guyenet at 11:02 PM 34 comments

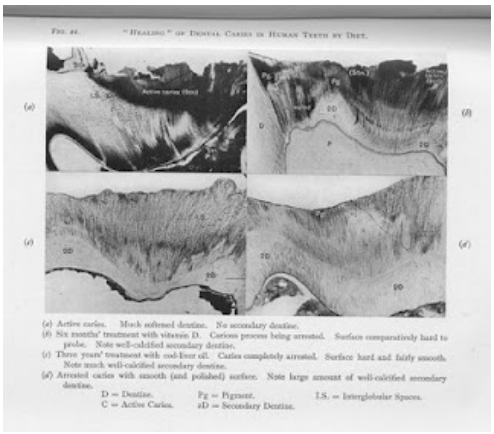
Recommend this on Google

Labels: dental health, diet, disease, diseases of civilization, Pima

Wednesday, April 15, 2009

Images of Tooth Decay Healing due to an Improved Diet

This one's for the skeptics out there. As I mentioned in my previous post, Drs. Edward and May Mellanby and Dr. Weston Price reported that under the right circumstances, tooth decay can be reversed by proper nutrition. Here are images taken from the book *Nutrition and Disease*, by Dr. Mellanby, showing the re-calcification of decayed human teeth due to the growth of tertiary dentin (formerly known as secondary dentin). These are sections (slices) of teeth that have been treated with a chemical that darkens decayed areas. They represent four different teeth at different stages of decay reversal. Click on the image for a larger view:



Here's the text that accompanies the figure:

> The hardening of carious areas that takes place in the teeth of children fed on diets of high calcifying value indicates the arrest of the active process and may result in “healing” of the infected area. As might be surmised, this phenomenon is accompanied by a laying down of a thick barrier of well-formed secondary denture. Illustrations of this healing process can be seen in Figs. 21 (b), (c) and (d). Summing up these results it will be clear that the clinical deductions made on the basis of the animal experiments have been justified, and that it is now known how to diminish the spread of caries and even to stop the active carious process in many affected teeth.

The following reference contains a summary of Dr. May Mellanby's experiments on healing tooth decay in children using diet: *Mellanby, M. et al. British Medical Journal. Issue 1, page 507. 1932*. The diet they used was typically a combination of some source of vitamin D (cod liver oil or irradiated ergosterol), plus liberal full-fat dairy, meats, eggs, vegetables, potatoes and grains low in phytic acid such as white bread. The most effective version of his diet, however, did not include grains.

In the book *Nutrition and Physical Degeneration*, Dr. Price provides X-rays showing the re-calcification of a mouth full of cavities using a similar diet.

Posted by Stephan Guyenet at 3:16 PM 35 comments

Recommend this on Google

Labels: dental health, diet, phytic acid

Sunday, April 5, 2009

Dental Anecdotes

Here are a few anecdotes gleaned from past comments that describe improvements in oral health due

to a change in diet. Please feel free to add your own (positive or negative) experience to the comments. I may add it to the post.

Stan: My teeth stopped decaying and some breakage (broken tooth due to mechanical damage, 5 years ago) begun sealing itself with new enamel on my high animal fat, low carb diet of the last 10 years. I still have all my teeth including wisdom teeth. My teeth no longer develop plaque/scale and thus no need to descale, and I no longer develop cold sores on my gums. I haven't been to a dentist since 1999 (I am 53). [From another comment] I can fully confirm the astounding effect of a diet very high in animal produce and low in plants, on my teeth. My tooth decay has totally stopped! I wrote about that before but it is worth repeating: - my teeth would not decay even if mechanically damaged, broken in half etc. The broken exposed parts of a tooth, even if the core is open, just seals itself over time.

Dave: Our family has had similar experiences. In particular, my daughter had a poorly formed molar (she was a spring baby, before we started Vitamin D, hmmmm). The tooth had quite a large crater in it. I put her on D3 and cod liver oil/butter oil. We finally got a dentist she'd cooperate with enough for X-rays. The result was exactly as described above: a thick layer of dentin had formed. The dentist was thoroughly puzzled, which I enjoyed immensely :-)

Arnoud: For years my dentist has been insisting on more frequent and more aggressive cleaning techniques.... to no avail. Last year I started Vitamin D supplementation, and a more Paleo style of diet, and the 'chronic' inflammation of my gums resolved themselves within days, literally. My dentist claims it is a coincidence. I think not!

Martin: Once I changed my diet to one close to what is listed in this entry, and added a vitamin D3 supplement, my dental health greatly improved. No more cavities, and beyond that, no more rapid build-up of dental plaque. To prevent gum problems, I used to have to get my teeth cleaned four times a year, now, once a year is enough, and it seems to me, even that might not be necessary.

Thresshold: I am a cavity-every-six-months person, who arrested decay for 3 years by going on a Protein Power-like diet. No limit on non-starchy veggies, lots of meat-- turkey, beef --lots of nuts, olive oil, egg a day. No grains. Very little fruit, no sugar. Plenty of supplemented vitamin A and D, E, C, Bs, some dolomite.

Jeff: I just had a dentist visit, first in almost 3 years. No cavities for the first time in a while. Your advice and a Paleo diet are the reason, in my mind.

Dr. Dan: Before paleo I had bleeding gums and sore teeth. Now that I have been on it I have not had them and my flatmate just commented how white my teeth are looking.

Cheeseslave: I have also eliminated cavities since I changed the way I eat. I avoid all phytic acid (I try to only eat sprouted bread or naturally fermented sourdough) and I soak or sprout all my grains, legumes, nuts and seeds. I also take cod liver oil, and eat a nutrient-dense diet consisting of mostly meat and dairy.

Dr. B. G.: Myself, I had periodontal disease (esp immed after pregnancy and lactation -- wonder W-H-Y ??!) however at the last check up -- I have no more pockets of '5' and am released to come in only 2x annually instead of all the extra (painful) de-planing and cleanings. This was improved by: vitamin A, vitamin D 5000 IU every am, high dose fish oil, flaxseed and egg yolks and saturated fats and some K2 supplements. [From another comment] I have to admit -- my dental problems reversed prior to total Paleo eating (eg, wheat-free). On vitamin D and fish oil alone my cavities sealed. In fact I had gone back to see the DDS but he couldn't find one tiny 'sticky' spot. When he decided to fill it irregardless (and I was an idiot to not walk out b/c who knew that cavities could heal/seal...on their own??), then I had to leave him. At that point, the dental hygienist had already let me return to a 'normal' insured 2 cleanings/yr schedule, instead of the $$ 4/year (where 2 were out-of-pocket). With going 100% wheat-free, vits ADEK and adding a little (fresh highquality) flaxseed oil, my gums are super healthy and no throbbing at all for the last 9mos!

Brock: When I went to my dentist for the first time in a while last September I was told I had six cavities. My dentist told me to schedule to get them filled in, but I never did. I just had the intuitive feeling that the human body ought to be able to heal itself, and that for some reason my dentist just didn't know how. So, I started Googling. My search lead me here and to the Weston Price Foundation. I bought Dr. Price's book and changed by diet months ago. I eat mostly paleo but mainly just focus on avoiding wheat, corn, sugar and n6 fats. I supplement with Vitamins A, C, D, E and K2. Long story short, my six cavities have closed up and my teeth have noticeably improved in color and "feel". Swelling in my gums is down. I can often go for weeks now without brushing my teeth without any noticeable side effects. It's great.

Andrew S.:I had a lot of cavities growing up, and as a young adult. I started up a new company, didn't have health insurance, and didn't go to the dentist in a while -- and started eating whole, natural foods, with a bit of supplementation (mostly cod liver oil). I was surprised when I visited the dentist for the first time in years to not have any decay.

Robert Andrew Brown: I too have gone from regular cavities, indifferent gum health, sensitive teeth, and a host of dental work to prove it, to none since balancing the Omega 3s and 6s, and regular 'industrial' cod liver oil. Small carries that were sensitive and on the list for restorative work have re mineralised and skinned over but not refilled. I have only recently started seriously increasing vitamin D and reintroducing grass fed butter.

Posted by Stephan Guyenet at 8:17 PM 29 comments

Labels: dental health, diet, success stories

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