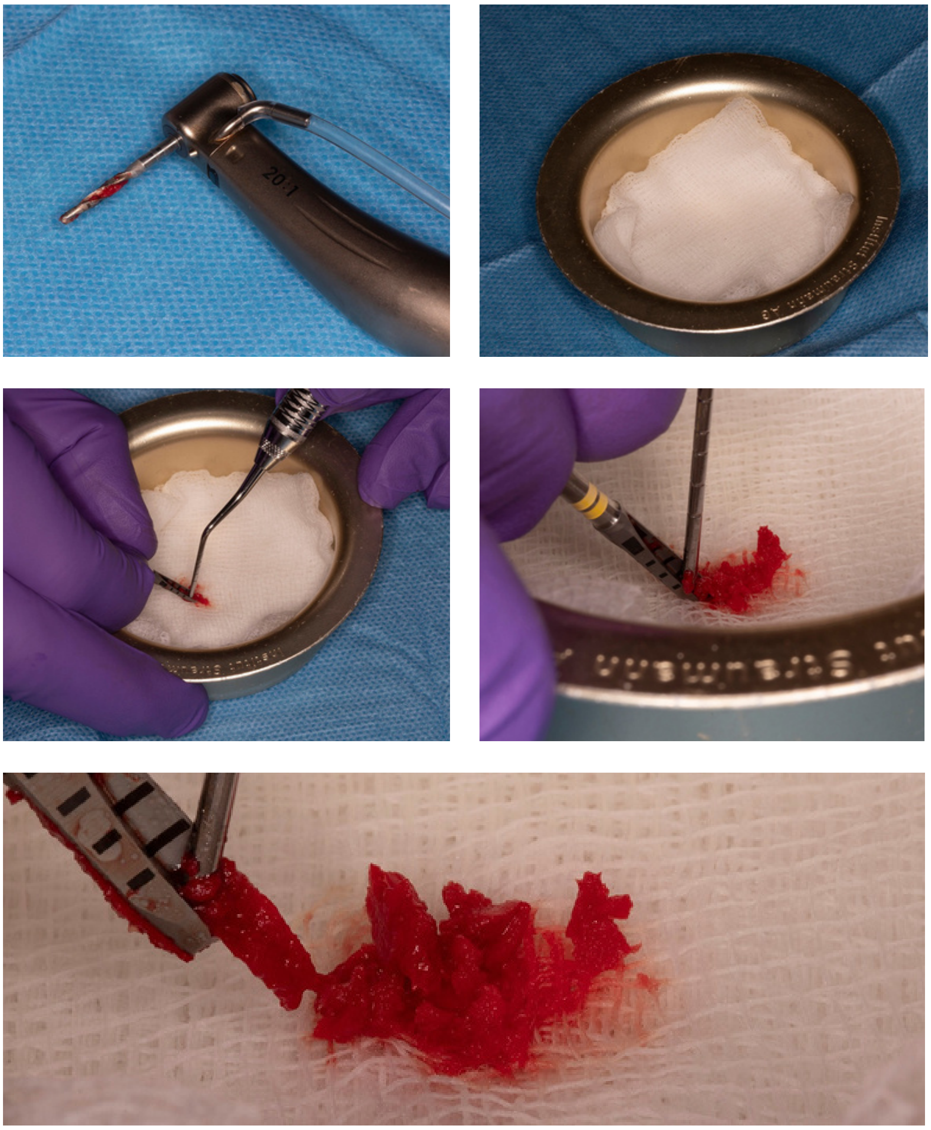
A slow drilling osteotomy protocol

Aly Virani digs deeper into the evidence surrounding temperature changes on bone to examine why faster does not necessarily mean better in implant preparations

Conventional osteotomy preparation in modern implant dentistry involves the use of saline irrigation and drilling speeds ranging from 800 to 1,200rpm.

These high speeds reduce the amount of friction produced while the irrigant limits temperature increases in the bone, and the process allows for quick osteotomy preparation. Osseointegration rates are high and the process is predictable. So why consider changing this?

The evidence contains hidden clues that may have implications beyond initial osseointegration. Perhaps conventional osteotomy preparation protocols could be leading long-term complications around implants that are still not properly understood. Slow drilling and the reduced potential for temperature increase in the alveolus might be a solution to some late complications around implants that are not yet fully understood.



FIGURES 1A-1E: Bone can be harvested directly from the drill flutes. Harvested bone should be placed on saline-dampened gauze – never submerged in saline. In theory, this dampened gauze will keep bones cells vital for around half an hour

Regardless of the possibility of the impact on long term peri-implant tissue health, slow drilling could also positively impact surgical techniques and protocols for bone grafting and guided surgery.

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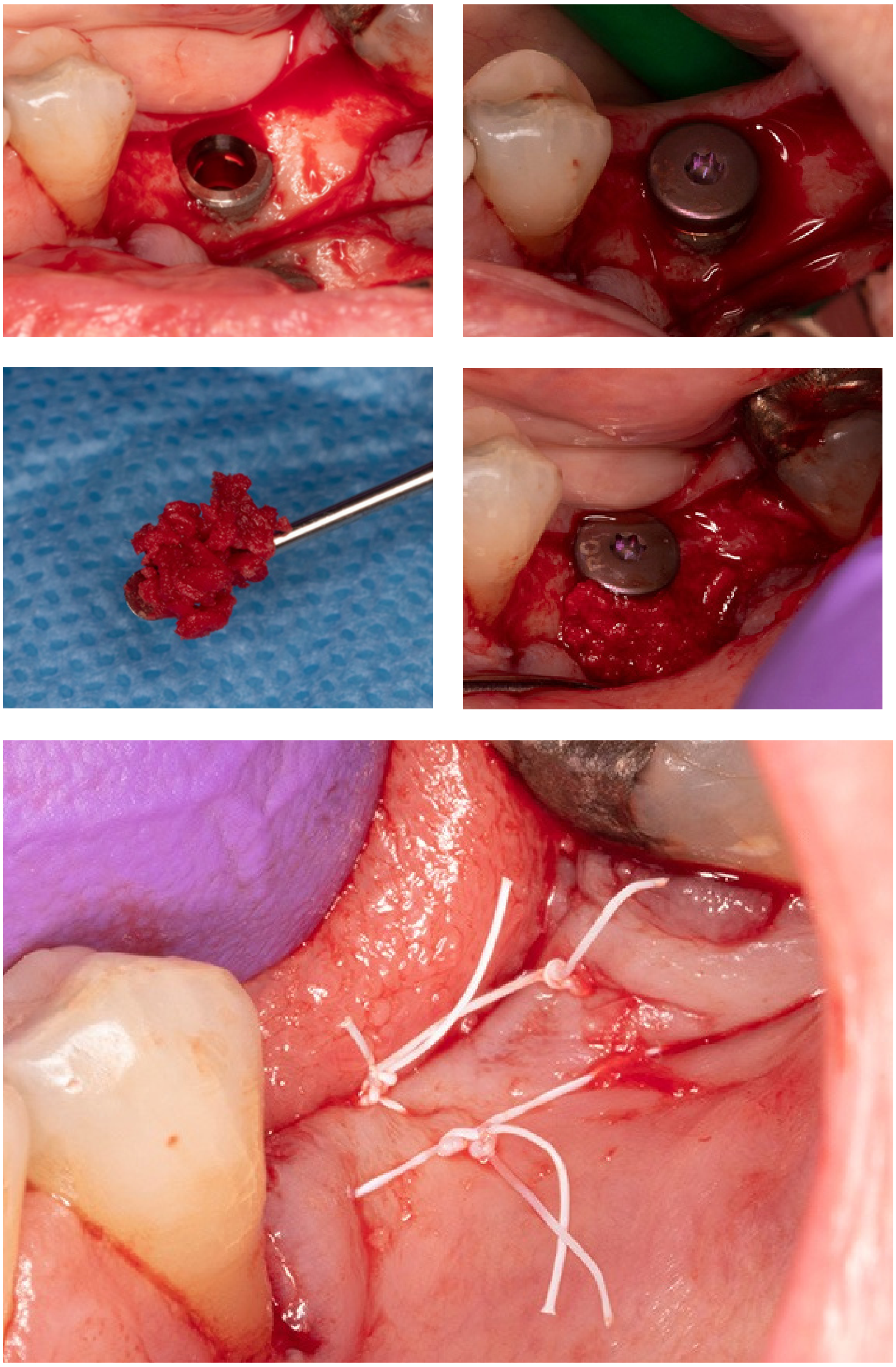
Aly is currently an elected representative on the executive committee of the Independent Dental Association Wales and an ambassador for the Young ITI (International Team for Implantology). He is currently the Welsh representative on the board of directors of the Association of Dental Implantology (ADI. He is a member of the Joint Dental Faculties of the Royal College of Surgeons (England) and remains an active member of the Association of Dental Implantology. He continues to lecture (and learn!) in the national forum.

Aly currently spends his time travelling between three dental practices; his newly acquired practice (North Cardiff Dental & Implants), The Mayhill Dental & Specialist Centre (an independent practice in Monmouth) and Portman's Hereford Dental & Implant Clinic.



FIGURES 2A-2E: Bone harvested using this protocol retains bone morphogenic proteins and growth factors. As the gold standard for grafting, it can be used to augment the implant site

Understanding temperature

In order to understand the potential benefits of slow drilling, the history of the research of temperature effects on bone metabolism and the scientific basis of the practical consideration of the protocol must first be understood.

At the beginning of the 1980s, research teams struggled to devise a methodology that would allow for the testing of temperature increase on bone health.

It was therefore agreed that temperatures above 56°C would be harmful to bone as this is the temperature at which alkaline phosphatases denature. These hard tissue proteins are found in many tissues but they are essential for the process of osteogenesis.

Then, in 1982, a research team from the University of Gothenburg led by Tomas Albrektsson did a study on hares using live microscopy to look at the effect of heat on implants that were placed into the hares' bones. They noticed that above 40°C hyperaemia occurred in the tissues and at 53°C blood flow stopped completely. Following ischaemia it took four to five weeks for the vasculature to recover.

Their connective tissue observations were dominated by the behaviour of fat cells. After being heated at 53° for one minute, the fat cells appeared necrotic after two days. After three weeks most fat cells were resorbed.

Functional vasculature is needed for the resorption and replacement of new cells, suggesting that the vasculature had recovered at the six-to-eight-week mark where fat cells were reaching their original numbers. At this point bone resorption dominated the picture and alerted the team to the possibility of the loss of bone being related to the behaviour of fat cells. It also confirmed that the safe temperature for bone is below 53°C.

Underestimating damage

This study by Albrektsson's team also highlights the danger with many other studies that have looked at the effect of temperature on bone – they underestimate the damage caused to bone cells by temperature increases.

They often look at the immediate histological impact on the bone cells without taking into account the fact that the heat damage occurs weeks after the tissue has been injured, likely to be a secondary result of ischaemia.

Maintaining the blood flow is therefore critical, and this is a concept that the team from Sweden focused on.

Research subsequently carried out by the same team found that at 50°C for one minute and 47°C for five minutes, 30% of the bone around implants was being resorbed. They theorised that this was due to fat cell invasion, which occurs when, with greater insult, larger proportions of fat cells undergo necrosis. As the vasculature recovers, fat cells are regenerated and these new fat cells invade the surrounding bone more aggressively than existing fat cells would do had they been preserved.

The greater the thermal trauma to the connective tissues, therefore, the greater the degree of bone resorption that follows. When exposed to 47°C for a minute,

some sites only experienced 10% bone resorption. Others experienced up to 30% resorption. This study therefore concluded that 47°C for one minute is the border temperature for the occurrence of bone tissue damage.
But the inconsistency in bone resorption rates at this temperature suggests that this is an unpredictable and potentially dangerous safe temperature to accept.

Perhaps the greatest confirmed benefit of the slow drilling protocol is the bone that is harvested from the drill flutes

Further investigation

The team's research thus continued along the same path, with multiple studies leading on to each other, using this tried and tested methodology.
They found that at 50°C for one minute there was a loss of bone and vascularity adjacent to the implant. At 47°C for one minute there were histological differences from normal bone, but this is the safe temperature that is still quoted in some in vitro studies that look at temperature changes when placing implants with guided surgery. Caution should therefore be exercised when considering the modern evidence in this field.
At 44°C for one minute the team found no differences from histologically normal bone, but that seven minutes at this temperature could potentially cause bone damage.
By the end of the 1980s, we had the evidence to suggest that both the temperature and duration of exposure are important for bone health, and these figures have not changed much since.

The literature often suggests that 44°C is the safe limit and some studies continue to quote 47°C as the safe limit.

I am just explaining why, as a generally risk-averse implant dentist (is that an oxymoron?) I consider 40°C to be my accepted safe temperature where possible. It would be rare to spend anywhere near seven cumulative minutes on a single osteotomy preparation.

Why slow drilling?

So why have I dragged a reader who – if you are anything like me – wants to know the relevant, practical aspect of a slow drilling protocol through so much of the history of the research of bone temperature research?
The answer is that it is important to appreciate that there is a solid evidence base behind this technique – but that there might also be some hidden clues into the modern clinical problems that we face in implant dentistry.
With the advent of social media as a form of 'study club' in modern implantology, conversations surrounding implant problems centred on a clinical case are becoming more common.
On closed forums such as the Association

of Dental Implantology (ADI) Members' Forum on Facebook, one such case showed the loss of integration of an implant that had been successfully integrated for five years.
The most frequent reasons for this tend to be fremitus or peri-implantitis but the atypical radiographic appearance suggested that this was not the case. The resulting debate led to a colleague suggesting that this may be down to a 'late reactionary process', which made me wonder whether the fat cells could be playing a part here.

What if the degree of soft tissue healing around an implant can have an impact later on? What if the fat cell invasion that causes initial bone resorption could be minimal enough to allow for osseointegration, but leads to some connective tissue forming around an implant that later precipitates a loss of the integration?

We don't know what we don't know, but what if a protocol that reduces the risk of fat cell invasion were to save us from these late complications? Enter the slow drilling protocol.

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The slow drilling protocol

The slow drilling protocol being described here has been developed in order to stay well within the margins of temperature safety and buffer the temperature rises that may be caused by more dense bone, less sharp drills and extra time being taken to prepare an osteotomy.
Minimising surgical trauma is key and although the above evidence exists, a degree of extrapolation has had to be used in order to translate this into clinical protocols.
The best available research into the practical considerations for slow drilling has been produced by Eduardo Anitua and his team at the Biotechnology Institute (BTI) in Vitoria, Spain. There he has developed a state-of-the-art clinical facility that is attached to a prolific research department. I can personally attest to the quality of courses that they provide and found my visit to this facility to be awe inspiring.
Their 'biological drilling protocol' was published in 2007 and was a combination of slow drilling with a form of blood derivative called Endoret. Regardless of your stance on the use of blood plasma in implant dentistry, consider the slow drilling side to this protocol.
They suggest the use of a sharp initial drill (referred to in different systems as a lance, needle or spade drill) at 800rpm with saline irrigation. This allows for the penetration of the cortical bone, reducing friction and the resulting temperature increase that would be caused by the subsequent drills. It also allows access to the cellular underlying bone. There is no evidence for this initial drill speed and in practice this step can be carried out at 150rpm with drip irrigation from a diabetic syringe.
Following this, there is evidence to suggest that the pilot and twist drills can be used successfully at 20-80rpm with no irrigation. Anitua's publication suggests a speed of 50rpm, which buys you a safety margin by staying mid-range.
The team found that this speed led to the bone temperatures at the tips of these drills increasing to 28°C, which is well below our established safe temperature.

On a practical note, this slower speed does not mean that more pressure should have to be placed on the handpiece in order to prepare the osteotomy.
Clearing the bone that has collected in the drill flutes should improve the cutting efficacy, but if this does not work then it suggests that the burs are not as sharp as they need to be. Using this protocol will keep your burs sharper for longer but any blunting is a lot more noticeable.

Perhaps the greatest confirmed benefit of the slow drilling protocol is the bone that is harvested from the drill flutes, which can be recycled.

Anitua's team did a split mouth study to compare the bone that is harvested this way versus that collected via bone traps when using a conventional drilling protocol with irrigation.
When drilling at 1,200rpm, the cells from within the bone are lost and the trabecular structure that facilitates angiogenesis is partially destroyed.

Bone morphogenic proteins and growth factors, some of which are present in the tissues and some are produced in response to injury, are water soluble and thus washed away by the irrigant.
Conventional drilling also ruins the extracellular matrix that these signalling molecules attach to, so they cannot reach and stimulate the cells that would initiate the repair of the surgical damage. A slow drilling protocol allows for bone to be harvested that has the correct trabecular structure and is rich in signalling molecules.

The recipient site has a transport network, the extracellular matrix, which is able to facilitate their movement, allowing for faster and more successful graft integration.
The bone that can be harvested is the gold standard for these osteoconductive and osteoinductive reasons.

The bone can be harvested directly from the drill flutes, using a sterile instrument. It should be placed onto sterile gauze that is dampened with saline – it should not be submerged in saline as this leads to the loss of the soluble signalling molecules. Theoretically, this dampened gauze can keep the bone cells vital for the half hour or so that would be needed between harvesting and use of the graft material.

Additional benefits

Slow drilling includes additional surgical benefits. The patient comfort and operator vision are improved as a result of avoiding the need for irrigation.

Greater tactile feedback allows for more accurate assessment of bone quality which is helpful in determining drill sequence and loading protocols.
The resistance offered by cortical anatomical boundaries can also offer guidance and safety when working in difficult circumstances: the palatal shelf guiding the drill in a narrow ridge, for example, or the floor of the sinus providing resistance to decrease the risk of unplanned perforation.
The speed of drilling also allows for more time to react during surgery, for example when placing implants close to the inferior dental nerve under infiltration anaesthetic.

As guided surgery becomes more popular and more common, the effect of irrigation not reaching the surgical site through these guides may lead to late complications. Using a slow drilling protocol in conjunction with guided surgery could help to avoid potential temperature increases and the resulting complications.
Although implant systems have been designed to be used with a slow drilling protocol, for example BTI's implant system

and more recently Nobel Biocare's N1 system, I am yet to come across a system that does not lend itself to slow drilling effectively. Perhaps using a design specific system will prove to be of even greater benefit in time. Using a slow drilling protocol will take up a few more seconds of your time but the immediate and long-term effects might save you a lot of trouble and make your surgery workflow easier.

So, once you have pierced the cortical bone, turn your drill speed down to 50rpm, turn off your irrigation and enjoy access to a new type of surgery that results in an abundance of easy to handle, effort-free autogenous graft material. What have you got to lose?

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