The Technique Behind Osstell and its Correlation to Torque and BIC

Resonance Frequency Analysis

Resonance Frequency Analysis (RFA) is the measurement of the frequency with which a device vibrates. There are several detection methods for the resonance frequency, one of them is to listen to the sound of the vibration frequency in the audible range. By comparing resonance frequencies, the stability of a dental implant can be determined as the resonance frequency changes with different stabilities. A sensor is mounted on top of the implant and the sensor is then brought to vibration by gently moving it with magnetic pulses. The sensor will vibrate for a short while and then stop. If the implant stability (stiffness of the bone-implant interface) increases, the vibration frequency of the sensor will increase.

ISQ

ISQ is short for "Implant Stability Quotient". The ISQ-scale runs from 1 to 100 and corresponds to the resonance frequency in a close to linear way. The reason for using ISQ instead of the resonance frequency expressed in Hz, is simply because it is easier to communicate. The scale was determined in 2003, and ISQ 1 correspond approximately to 1,000 Hz and ISQ 100 correspond approximately to 10,000 Hz. The early scientific studies were used to determine how the ISQ scale should relate to Hz and numerous clinical studies after that have put the ISQ-scale in a clinical context, relating to treatment adn loading protocols.

ISQ, Micro Mobility and Micro Motion

The Osstell technique is an indirect measurement of osseointegration. It measures the resonance frequency of the connected Smart-Peg which reflects the micro mobility of the implant. This way of measuring has several advantages compared to direct techniques like "knocking" (percussion based techniques) on the implant.



The influence of the mass of the implant will be minimal and the very low energy transferred to the implant is noninvasive. The measurement is totally objective; no matter who is using the system, the result will always be the same. The measurement is accurate, repeatable and can be used to monitor osseointegration without jeopardizing the biological process.

Micro Mobility

The distance the implant moves when subjected to 1 N lateral load 10 mm above bone level, here expressed as $\mu m/N$. The load is applied at a certain distance from the bone level.

Micro mobility is determined by e.g. bone density in general and the degree of osseointegration, preparation of the implant site and the implant design. The correlation between micro mobility (μ m/N) and ISQ is non-linear and micro mobility is reduced with app. 50 % when ISQ increases from 60 to 70 ISQ.

Micro Motion

The distance the implant moves, when subjected to a determined lateral load, in µm.

Micro motion = micro mobility $(\mu m/N)^*$ load (N)

Depends on the degree of micro mobility and the applied load e.g. bite force, no of implants and prosthetic design. The correlation between micro motion (μ m) and load (N) is linear, the more lateral load the more micro motion. The same load (N) will give different micro motion (μ m) in different bone quality.

It is well known that too much micro motion will jeopardize the osseointegration process. Scientific ISQ data indicates that implants with high ISQ-values seem to withstand even high forces in the mouth and still osseointegrate. This is also well in accordance with the theoretical model.

ISQ and Torque

Torque is sometimes used to describe the stability of an implant. However, torque does not necessarily correlate to implant stability. Torque measures the rotational friction between the implant and the bone combined with the force required to cut the bone if that is the case, and the pressure force from the surrounding bone.

What is torque?

Dental implant torque is normally measured in Ncm. 10 Ncm corresponds to having a 10 cm lever attached to the implant, and pushing it at the end, with the force of 1 N (0.1 Kgf).

Insertion Torque

Insertion torque is torque measured continuously while the implant is inserted. The torque corresponds to a combination of the cutting friction of the tip of the implant in the bone, and the friction between the implant surface and the hole in the bone. If the hole is narrow or the bone quality is high the torque will be higher. The torque will also depend on how sharp the cutting tip of the implant is, on the surface properties of the implant, on the lubrication of the preparation (blood), and also on the design of the implant itself. For instance if the preparation is cylindrical and the implant is tapered, the insertion torque will be higher. The torque will increase as the implant goes down in the bone, due to the increased bone-to implant friction as the implant surface in contact with bone increases. Maybe the most important factor is the diameter of the implant, a wide implant to its contacting surface is longer and the implant surface itself is larger for a wide diameter implant.

Seating Torque

The seating torque is the final torque value achieved when the implant is inserted. Depending on the implant design and bone properties, the value can be higher or lower. A tapered implant or an implant with a flange can give a high seating torque even in soft bone. Soft bone with a thin hard cortical plate can also give a high seating torque even if the stability of the implant is poor. For instance in a jaw with poor quality bone and a thin cortical plate, a large portion of the implant will be surrounded by poor bone and the overall stability will then be low. If the cortical plate is thick, the stability will be higher, but the seating torque might be the same since the seating torque mainly consists of torque due to the tapered part or flange is hitting the hard bone.

Torque Test

Reverse torque or abutment tightening torque is sometimes used to test the friction between the implant and the surrounding bone. The friction depends on how much close bone contact there is (osseointegration) and the compression forces between the bone and the implant. The method has been criticized since it can jeopardize or destroy ongoing osseointegration.

ISQs' Correlation to Torque

In Degidi et al (2010), it is shown that even if ISQ and seating torque correlate in many cases, seating torque can be a poor measure-

ment of implant stability in other cases. This is further investigated in for instance Trisi et al (2010), which show very good correlation between ISQ and implant micro mobility but a less good correlation between seating torque and micro mobility. In Pagliani et al (2012) a very good correlation between ISQ and implant micro mobility is also shown. Torque is not a good baseline for further comparison since testing it could jeopardize ongoing osseointegration, as it is invasive.

ISQ and Bone to Implant Contact (BIC)

Bone to implant contact (BIC) is the percentage of the implant surface in contact with bone on a microscopic level.



Young's Modulus, Stability and Micro Motion

If the E-modulus (Young's modulus) is high, in any material, it means that the material stiffness is high. If a tapered screw is screwed into hard wood for instance, the stability will be high due to the relatively high stiffness of the wood. Such a screw will move very little when subjected to forces (low micromotion) even if the "screw-to-bone" contact might be in the range of 50 % or lower. Even if the screw is glued in place and thus increasing the "screw-to-bone" contact to 100 %, the stability will not increase significantly since the stability was already high from the beginning. This reasoning is valid for practically all solid materials, including dense bone. For the reasons above, BIC does not have a linear correlation with implant stability. Osstell (RFA) measures the implant stability by measuring the stiffness in the interface between the implant and the bone which in turn is a measurement of the micro mobility (µm /N).



In Soft to Medium Bone

When the initial stability is low to medium, osseointegration will change the bone around the implant so that the stability and stiffness increases (and also BIC). In this case there will be a good correlation between ISQ and BIC.

In Dense Bone

When the initial stability is high (e.g. above 75 ISQ), osseointegration will not add stability to the implant in a significant way. Even if the BIC is increasing, the implant stability will not change much, which is reflected by the ISQ value. In this case, the correlation between BIC and ISQ will be poor.

Failing implants

For implants that does not integrate, the stiffness will decrease and the stability will go down. This will be reflected by the decreasing ISQ value. The above implies that it is possible to have relatively high BIC but low ISQ in soft bone, and low BIC with high ISQ in dense bone.

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