

ON STANDARD CALIBRATION OF ISQ TRANSDUCER PEGS.

Prerequisites for accurate and comparable RFA measurements.

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ABSTRACT: The resonance frequency analysis (RFA) technique is widely used for stability assessments of dental implants. The technique makes use of a transducer peg, which is attached to the implant and excited over a range of frequencies by electro-magnetic waves to measure the resonance frequency (RF) of the peg. The underlying RF in Hz is then translated to an Implant Stability Quotient (ISQ) on a scale of 100 ISQ units. It is of importance that different implant types with the same stability show the same ISQ value. One potential problem with the first RFA technique is that the different pegs for different implant types have not been properly calibrated. Research has shown that ISQ values correlate well with bone density at the implant site, i.e. interface stiffness and clamping ability of the surrounding bone. The present paper presents a novel technique for standard calibration of the new generation of ISQ transducer –the MulTipeg™.

INTRODUCTION

The ISQ unit is a unique quantity used to describe the outcome of RFA (Resonance Frequency Analysis) measurements of bone-anchored implants¹. It was introduced in 2001 and derives from a simple linear re-calculation of the range of resonance frequencies (RF) in hertz (Hz) obtained from measurements of dental implants with the first generation of wire-bound transducers, so that²:

$$ISQ = \frac{(\text{Measured Frequency} - \text{min.frequency})}{(\text{max.frequency} - \text{min.frequency})} \times 100.$$

The formula shows that the ISQ unit is equal to a percentage of the original RF scale, i.e. an Implant Stability Quotient. This means that the highest RF obtained with the old transducers corresponds to 100 ISQ and the lowest RF to 1 ISQ.

Each wire-bound transducer of the first generation had its unique RF and certain calibration parameters had to be built into each transducer connector in order to get the same RF and subsequent ISQ value^{1,2}. This problem was overcome by introducing the wireless transducers (pegs), which due to the manufacturing process were identical and did not need to be individually programmed^{1,2}. The way ISQ was calculated from the underlying RF, however, had to be re-defined, since the pegs did not behave in the same way as the old wire-bound transducers when tested at differ-

ent degrees of stability. A new ISQ equation was determined by measuring the RF of implants with varying stability with both transducers and pegs in a laboratory setting. The equation (a fourth-grade polynomial) was also shaped in such a way that ISQ could not be higher than 100.

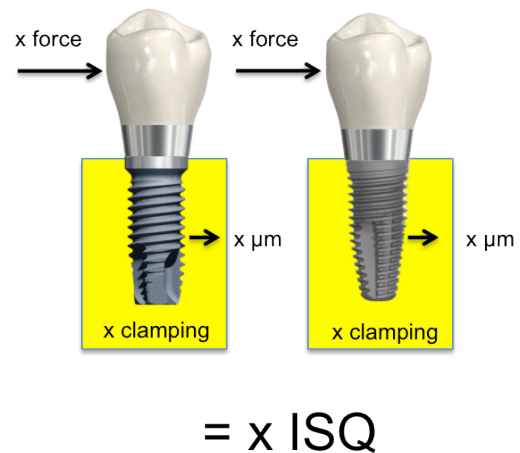


Figure 1. Two different implant designs with the same stability (same clamping, same micro-mobility) should show the same ISQ value.

Prerequisites for accurate and comparable ISQ measurements

It is desirable that different pegs for different implant designs give the same ISQ for the same implant stability (Figure 1). This is a known problem when calibrating transducer pegs for different implant designs, which is not that easy to solve, since implant stability *per se* has not been defined using any other quantity, i.e. a reference is lacking when pegs are designed and developed. This means that it is impossible to know if different ISQ values from two different implant designs depends on the fact that the two pegs are different or if the stability is actually different.

A solution to the reference and calibration problem

The ISQ-unit has not yet been defined using any other general or specific implant stability quantity, simply because there is no such unit available. However, studies have shown the ISQ value to correlate with other parameters such as bone density^{3,15} and micro-mobility^{16,17}, i.e. interface stiffness and clamping ability of the bone. This fact can be used when calibrating ISQ pegs for different implant types.

If all implants had the same outer geometry, calibration of transducer pegs would not be an issue as all measurements would be accurate and comparable. In reality, several hundreds of different implant designs are used clinically today, which may show different clamping and primary stability in the same bone density due to differences in surgical technique, implant design and self-tapping properties. The solution to the calibration problem is (i) to make sure that the implants are properly embedded in a dense material and (ii) to give all implants an identical outer geometry. This can be achieved by moulding each implant type into a cylinder of dense material. The stability of each implant/cylinder can then be controlled and varied with a clamping device in a standardized manner and the resonance frequency of the MulTipeg™ measured over a range of stabilities. Each peg type can then be calibrated to give the same ISQ value for the same stability by elaborating the physical dimensions of the peg.

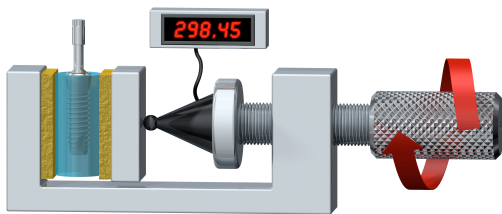


Figure 2. Specially designed rig for controlling clamping and stability of the embedded implant.

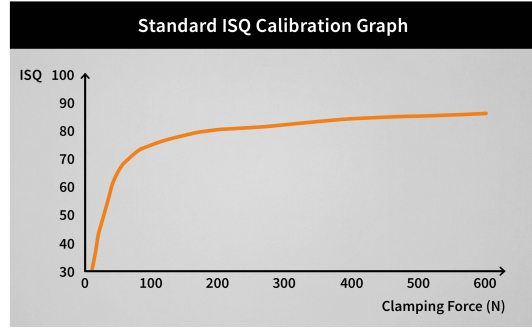


Figure 3. The Standard ISQ Curve showing the relation between clamping force (N) and ISQ values

Standard ISQ Curve

With this innovative method, a reference ISQ/stability relationship has been established based on the “mother transducer” (Type I), which is used when manufacturing MulTipeg™ for different implant designs. Each type of MulTipeg™ is designed to follow the whole range of the standard ISQ curve to assure that different types of implants show the same ISQ-value for the same stability, irrespective of in the lower or higher end of the curve.

Intrinsic and extrinsic variance of MulTipeg™.

The technique described above ensure accurate intrinsic calibration of all MulTipegs™. However, there is a risk that other pegs on the market perform differently due to the lack of extrinsic calibration between different peg systems. The magnitude of the variation is however currently unknown.

MulTipeg™-implant fit

The peg-implant connection is a potential source of erroneous measurements due to possible misfit. Therefore, MulTipegs™ are designed to achieve the best possible fit with each implant type. All MulTipegs™ types are calibrated against the ISQ Standard to detect any misfit or variance in ISQ, which in turn can be eliminated by elaborating the physical properties of the peg. For this reason there will more MulTipeg™ types compared to other pegs on the market. Another issue is that modern bone-level implants often use an internal connection for abutments and prosthetic devices. That is why some marginal bone overgrowth of the implant does not prevent a good fit. The MulTipegs™ are designed to bypass and avoid interaction with the marginal bone in order to prevent erroneous measurements, which is in contrast to some other pegs on the market.

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CONFLICT OF INTEREST STATEMENT

The authors of this review are partners of Integration Diagnostics Sweden AB.