British Institute
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CPD Article

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1hr

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Distortion and Bio-Mechanics of Implant Supported Prostheses

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Introduction:

Since the introduction of commercially manufactured dental implants in the 1980's, research has been on the forefront with numerous studies on the osseo-integration of implants. The lack of understanding of the technical field of distortion of impressions and models as well as the bio-mechanics of implant supported frameworks has led many dentists and dental technicians to believe that dental impressions, dental models and implant supported frameworks are accurate. CAD CAM frameworks have greatly eliminated problems associated with cast frameworks and has shown that a clinically acceptable fit can be attained on dental stone models[1]. However recent studies[2] have shown that master impressions cast with conventional techniques are suspect and do not represent the position of implants in the oral cavity accurately. Minute discrepancies in the registering of implant positions may lead to implant loss, screw loosening or breakage and patient discomfort. This article addresses these issues and tries to give a perspective to common technical errors that are introduced during the fabrication process of a splinted implant supported prosthesis in the laboratory.

Inaccuracies and distortion present themselves in all stages of the restorative process. This includes the impression and materials; casting of dental models with plaster and stone; waxing and casting of metal superstructures and addition of porcelain.

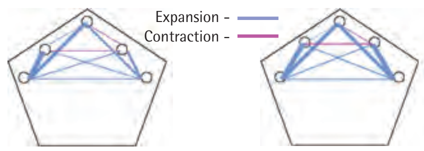

Fig 1: Magnitude of discrepancy for impression (polyether)

Fig 2 Magnitude of discrepancy for casts

Accuracy of Impression Materials:

The physical property requirements of ISO 4823:2000[3] for dental elastomeric impression materials states that a product should have a maximum dimensional linear change of 1.5% and the minimum elastic recovery should be at 96.5%. If you take an impression of an average dental arch, measure the distance between 16-26 (men: first molars: 48.1 ± 0.19 mm), (women: first molars: 46.7 ± 0.19 mm)[4] and do a basic calculation it will represent a distortion (using the ISO specification) of **721.5µm** for men. The mesio-distal arch length is much longer, which implies even greater distortion.

A material like Impregum® surpasses the ISO specification with an average of only 0.35% dimensional linear change[5] which represents a shrinkage of **168.35µm** (men).

Accuracy of Dental Models:

Dental stones on the market report a wide range of expansion figures, but are mostly in the vicinity of 0.08% (FlowStone) – 0.28% (Hard Rock)[6]. A resultant model produced from an Impregum® impression can therefore expect to be distorted as much as **134.68 µm (men)**. The distortion will be even more for the complete mesio-distal arch. While this is reported as expansion, and Impregum® distortion is a shrinkage, there is no evidence that these figures can be offset against each other.

Fig 3 Implant fractture

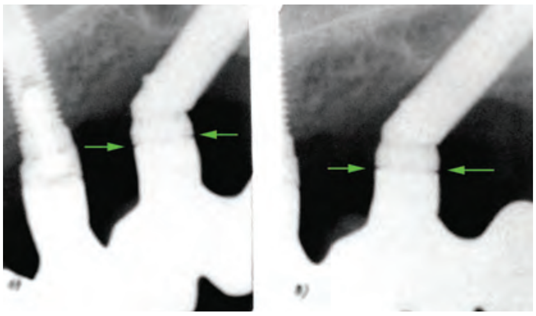

Fig 4 Noticeable misalignment

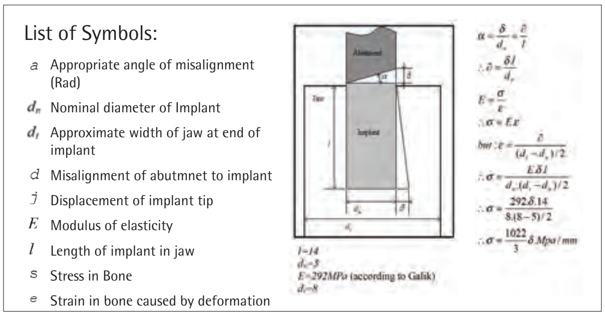

Fig 5 List of symbols

Von Berg et al[2] have tested these proprietary values in an in vitro study, using a commercial laboratory. Results show that the only non significant distortion between Impregum® and plaster impressions and their resultant casts exists across the arch from premolar to premolar. Significant distortion of 1.9% occurs along the arch of a long span implant cast.

Accuracy of Investment Materials:

A wide variety of investment materials are available with setting expansions that can be customized to compensate for metal shrinkage during the casting process. Mitha et al[7] report that even with strict control of investment distortion, the wax pattern of a full arch superstructure differs significantly from the resultant casting by an average of between **416 µm – 477 µm.**

Discussion:

This implies that it is not possible to create a perfectly accurate superstructure from a master model. When these are fitted to teeth, the adaptive capacity of the periodontal ligament accommodates for this distortion. However, when these structures are fabricated for implant supported prostheses the fit is more critical and the implications of misfit are more serious. Complications from this misfit include crestal bone loss, implant loss (See Fig 3), implant fracture, screw loosening and fracture, superstructure fracture, porcelain fractures and pain and discomfort. It is widely accepted that a passive fit of these structures on implants is therefore important. Jemt (1995)[8] indicates that a maximum misfit of 150 µm would be acceptable.

The following report[9] was done on load on bone due to misalignment.

The modulus of elasticity of bone10: Cortical - 15.474GPa, Cancellous – 292MPa 11 The modulus of elasticity of Ti (Grade 5) – 114GpaT12. Calculations of misfit is then easily established using the formula (See Fig 5):

Results are tabulated (Table 1).

Misalignment	Stress in bone at Incisors	
	MPa	Kg/mm2
30µm	10.22	1.04
60µm	20.44	2.08
90µm	30.66	3.12

With a misalignment of 1µm a force of 0.0347 kg is applied at every mm2 at the tip of the implant. This would imply a force of 5.20kg/mm2 (18mm implant) for an acceptable distortion of 150 micron. It is the authors opinion that these forces are most likely responsible for some of the complications included above.

An additional important consideration is therefore also the limitations of CAD CAM production of superstructures. As can be seen from the above information, these procedures only circumvent the distortion of waxing and casting procedures only, which represent the minor factors of distortion.

The scenario for zygomatic implants is even more frightening! (dn = 4)

(Table 2)

Implant Length	Misalignment	Stress in bone at Incisors	
ZYG-45mm		MPa	Kg/mm2
	30µm	49.27	5.02
	60µm	98.55	10.04
	90µm	147.82	15.06

A 150 µm misalignment will create an effective theoretical force of 25.1 kg/mm2 .

A discussion on a recent study[2] observes that: "It is not possible to make an undistorted impression or cast." One of their conclusions is: "Digital intra-oral scanning of the implants may be the future solution for more accurate reproduction of implant positions."

To eliminate as many of the factors of distortion and to improve the bio-mechanics in splinted implant metal frameworks the dentist and technician must strive to work as accurately as possible.

Factors that create problems during the manufacturing process include:

Fig 6 Impression pin X-ray

- the special tray
- impression coping placement
- the impression
- the model
- the casting
- and welding

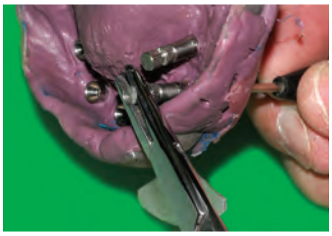

Fig 7 Use of an artery forceps

Fig 8 Section wax

Fig 9 Loose fitting matrix

Fig 10 Luted superstructure

Special tray:

The design of the special tray should allow for an even layer of impression material with adequate support for stabilization of the impression components. If self-cure acrylics are used the tray should be manufactured at least 24 hours before the impression. Trays manufactured with thermoplastic materials (heat pressure/vacuum machines) are preferred as they absorb less moisture. It should be of an adequate thickness and must be rigid.

Impression coping placement:

Impression copings should be placed, torqued and x-rayed to ensure proper fit to the implant- or abutment interface before the impression is taken.

The impression:

Impression material should be thoroughly mixed and applied to the special tray and impression copings without any voids. The use of a timer is essential and must be set according to the manufacturers instructions. After removal of the impression elastic recovery rates should be observed before the model is cast.

Preparation of the impression prior to pouring of the dental model:

Do not screw the replicas/analogues onto the impression copings using the support of the impression material (elastic deformation will occur).

Pouring of model:

Use only distilled water and vacuum mix with the correct powder: liquid ratios. Store plaster in a dry dust free place. Observe the shelf-life of the product. Do not remove cast from impression prematurely. Avoid rewetting if possible. The use of a dry model trimmer is strongly recommended.

Waxing and investing:

Wax the framework as accurately as possible. Separate the wax build-up with a fine instrument between the implant sections. (One implant per section). Sprue, invest and cast using manufacturer's recommendations.

Devesting and finishing of metal:

Devest taking care not to damage or sandblast fitting surfaces. Use an ultrasonic cleaner for final cleaning. Use tungsten carbide or ceramic bonded stones to finish surfaces. Assemble on model paying attention to the implant abutment interfaces.

Intra-oral luting:

The individual components are cleaned, screwed/torqued in position and all interferences are removed. An x-ray is taken to ensure accurate fit on the implant abutment interfaces. Using Dura-lay® or a light cure acrylic all the pieces of the framework are luted together, unscrewed, carefully packed and returned to the laboratory. If this is not possible a loose fitting cast matrix is used and secured around temporary components with Dura-lay® or light cure acrylic. This can then be used to alter the model to the new positions as registered with the matrix.

Altered cast model:

All but one of the replicas/analogues are removed from the model. An orientation line must be drawn on the side of the remaining implant/abutment interface as the

Fig 11 Top view

Fig 12 Model with replicas

Fig 13 Completed altered cast

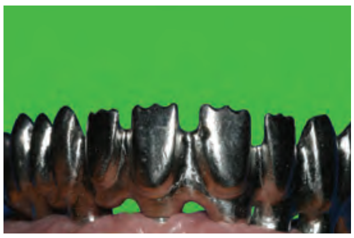

Fig 14 Cross section

components are non-engaging. This will ensure that the correct orientation of the metal framework is kept during removal of the other replicas/analogues from the model. The model is altered and the replicas/ analogues are screwed onto the framework and fixed into their new positions according to the luted metal framework. This model should give a precise representation of the positions of the implants intra-orally.

LASER/TIG welding:

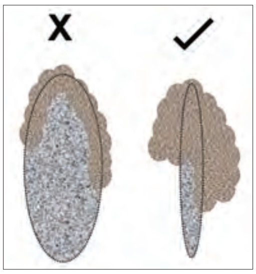

Fig 16 Passive components

After removal of the acrylic all sections are cleaned, screwed and torqued in position. A LASER or TIG welder is used to weld the different sections together. The correct way of welding is illustrated in **Fig 14.** The build-up should commence from the centre outwards. After welding the framework should be carefully scrutinized for imperfections in the welding seams. The metal framework can now be prepared to be overlaid with acrylic, composite or ceramic materials. **(Fig 15)**The passivity of fit is of utmost importance as distortion can also occur during the welding process. The use of "passive components" (Southern Implants – South Africa.) **(Fig 16)** is highly recommended for elimination of secondary introduced distortions. Titanium interface elements are cemented to the framework to compensate for slight misalignment prior to delivery of the final prosthesis.

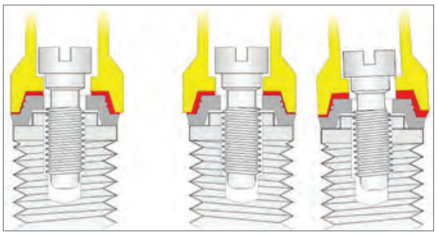

Fig 15 Finished welding

Conclusion:

Conventional impressions and model manufacturing does not give a precise copy of the intra-oral positions of implants. Even a few microns of discrepancy can lead to severe complications destroying the long term probability of an implant.

The following extract[13] rings true:

"The old concepts and formulas are no longer adequate to express our modern outlook. The old bottles will no longer hold the new wine. The spiritual temple of the future, while it will be built largely of the old well-proved materials, will require new and ampler foundations in the light of the immense extension of our intellectual horizons."

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Q1.) What is the specified maximum dimensional linear change for dental elastomeric impression materials?

a) 1.3% b) 2.5% c) 1.5% d) 1.4%

Q2.) In producing dental models which area of the arch is reported as having more distortion than others?

Q3.) How many hours prior to the impression being taken should a self-cure acrylic tray be manufactured.

a) 24 b) 36 c) 20 d) 21

Q4.) On construction of the model which type of model trimmer is recommended?

Q5.) Why must an orientation line be drawn on the side of the remaining implant/abutment interface?

6. During the welding process what type of components are recommended for elimination of secondary introduced distortions?

Name:

GDC Number:

Address:

Postcode:

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Signed:

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