Trial Application of Integrated Metal Mesh for the Denture Base

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The function and biocompatibility of the porous metal mesh plate of TRUTISSU for the denture base were examined. The TRUTISSU denture base fitted well to the master model with a high dimensional accuracy. The retention of the TRUTISSU denture base to mucous membrane was similar to that of the conventional denture base.

The mucous membrane under the TRUTISSU denture base was healthy. The porous metal mesh plate of TRUTISSU is a very interesting and effective material for the denture base.

Key words: Metal mesh plate, Denture base, Biocompatibility

INTRODUCTION

The retention of removable partial dentures is dependent upon the suction and adhesion between the denture base and mucous membrane. Therefore a wide area is necessary for a high retention of the denture and also to have homogeneous distribution of biting stress to the mucous membrane. Full dentures which cover the extensive area of mucous membrane inhibit the physiological function of the covered mucous membrane1-4. To minimize the adverse effect of the plate denture, we have developed an interesting new material for denture plates, which is porous to permeate oral liquid such as saliva and liquid ingredients of food for the maintenance of physiological functions of the mucous membrane under the denture plate.

This new material is the porous plate of metal mesh called TRUTISSU. We carried out in vitro experiments as well as clinical observations using this material.

MATERIAL

The integrated metal mesh plate TRUTISSU was made from the SUS-316 austenite type stainless steel which has been used in artificial bone and joint. This stainless steel consisted of 16-18% chromium, 10-14% nickel, 2-3% molybdenum, 2% manganese, 1% silicon and a small amount of carbon, phosphor and sulphur. It was excellent in tests of corrosion resistance and mechanical properties, 518 MPa in tensile strength and 40% elongation. This stainless steel has no problem regarding cytotoxicity or biocompatibility5. SUS-316 stainless steel was chosen as the base material because of its the high tolerance limit to biochemical and biomechanical stresses under the seven conditions of oral environment6. Possible contamination incurred by the fabricating process of the mesh plate was completely eliminated by cleansing the final product, so that TRUTISSU could be fabricated to have no cytotoxicity.
As shown in Fig. 1, TRUTISSU had the square grid structure, which was made by integrating the single layer mesh plate. The SUS-316 filament 60 μm in diameter was woven into a square mesh and several sheets were pressed and forged to make the final thickness of 0.4 mm. The mesh plate had a high permeability, as shown in Table 1. Three kinds of pore sizes of 2, 5 and 10 μm in diameter, were provided with 85% or more permeation of glass beads with the respective size. Each TRUTISSU plate had 40% to 50% porosity and TRUTISSU plate weighed only about a half of the conventional metallic plate of Co-Cr or Ni-Cr alloy7,8).

Fig. 1 Surface structure of TRUTISSU.

<table>
<thead>
<tr>
<th>Pore sizes</th>
<th>(Distribution of permeated glass beads)</th>
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<tbody>
<tr>
<td></td>
<td>&gt; 2 μm</td>
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<tr>
<td>2 μm</td>
<td>85%</td>
</tr>
<tr>
<td>5 μm</td>
<td></td>
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<tr>
<td>10 μm</td>
<td></td>
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**EXPERIMENTS AND RESULTS**

*Dimensional accuracy of TRUTISSU denture*

TRUTISSU is easily moulded with a high dimensional accuracy by swaging. TRUTISSU plate was fitted quite excellently to the master model. Poor fitting of the TRUTISSU dentures was experienced in many cases of clinical application in spite of the good fitting to the master model immediately after swaging. A large space of 1.5–2.0 mm was observed between the denture plate and the mucous membrane at the posterior margin. This space is caused by thermal shrinkage and/or polymerization shrinkage at the alveolar part of resin which would cause deformation of the TRUTISSU plate9–15).
The following experiment was carried out to analyse the pattern of deformation caused by thermal change and polymerization of the MMA resin. A full denture with a TRUTISSU plate was compared with that of the cobalt-chromium cast plate on the fitting at the posterior margin of a denture. As a control experiment, the PMMA resin denture of the same design was fabricated. The full dentures were placed on the master model to observe the unfit space at the posterior margin of the denture. In all full dentures, a large space was found. Among them, the TRUTISSU denture had the biggest space of 1.5–2.0 mm, followed by the resin denture (0.5–2.0 mm) and the cobalt-chromium denture (0.2–0.5 mm). To analyse the mechanism of the space formation caused by thermal and polymerization shrinkage, the metallic landmarks were set on the wax bite rim as shown in Fig. 2. The deformation of dentures was measured by shifting of the landmark before and after polymerization. In the case of TRUTISSU and cobalt-chromium dentures, the landmarks shifted to the buccal direction around the premolars and molars after polymerization. Around the anterior region shifting to the lingual direction was observed slightly (Fig. 3). This deformation was particularly remarkable in the TRUTISSU which had a 1.5–2.0 mm space between the master model and the denture plate at the posterior margin. It could negate the value of the occlusal relation of the trial wax denture obtained through careful adjustment in the clinical observation. On the other hand, cobalt-chromium dentures had a smaller space of 0.2–0.5 mm due to the high mechanical strength of cobalt-chromium, which may protect the deformation during polymerization of alveolar resin. It is natural that the cobalt-chromium denture has relatively good fitting. To eliminate the deformation, the residual stress in the alveolar part of the resin was released as follows. The alveolar part of the resin at the interproximal area of cuspid and premolar in both sides were sectioned and separated with a disc and the fitness was observed on the master model. Each denture plate became fit in the posterior margin, as shown in Fig. 4. This means that TRUTISSU and cobalt-chromium dentures have recovered their dimensional accuracy by releasing the residual stress in the alveolar part of the resin. The landmarks were shifted to the lingual direction beyond the original points by releasing in the TRUTISSU denture (Fig. 3). Another problem caused by complicated three-dimensional distortion still remained because the measurements in this research were two-
Fig. 4 Space formation at the posterior margin of dentures due to shrinkage before sectioning (A). The space is improved by sectioning the alveolar part of resin (B).

Retention of denture by suction and adhesion

Whether the suction power of porous TRUTISSU to mucous membrane is different from that of other non-porous materials was examined. TRUTISSU was cut into discs of 30 mm diameter with a 0.4 mm thickness and the pore size of the test pieces was 2, 5 and 10 μm. Test pieces of cobalt-chromium alloy and PMMA resin were used as control materials.
The test pieces were pressed to the artificial mucous membrane made of agar by a 200 g loading. A special loader was set with a hook attached to the test piece to give the tensile load, and the retention of the test piece to the artificial mucous membrane was measured after the tensile load was detached to the test piece. Artificial saliva with a viscosity of 0.01, 0.05, 0.1, 0.5, 1.0 and 2.0 poise was used between artificial mucous membrane and the test piece (Fig. 5).

Viscosity of less than 0.1 poise was a low retention, and a viscosity higher than 0.5 poise had a higher power of retention in proportion to the increase of the viscosity of the artificial saliva, so that there was no significant difference in the retention power among all test pieces of TRUTISSU, cobalt-chromium and PMMA resin. Therefore, in the oral cavity, the retention power of TRUTISSU may be kept with the presence of saliva which has a high viscosity 1.0 to 1.3 poise. The TRUTISSU denture could have a retention power equivalent to that of the conventional denture with cobalt-chromium and a PMMA solid plate.

It is, however, difficult to relate directly these in vitro results to the clinical cases. 

Biocompatibility

No pathological finding has been observed in the oral cavity clinically. The tissue under the TRUTISSU denture has kept the normal state. In some cases, pathological symptoms of hyperemia and chronic inflammation in mucous membrane disappeared by changing the resin dentures to TRUTISSU dentures, and healthy mucous membrane was recovered.

The biocompatibility of SUS-316 stainless steel has been reported by Kawahara et al. The tissue culture test was used to evaluate the cytotoxicity of TRUTISSU, and to compare it with that of the cobalt-chromium alloy and PMMA resin, each test piece was placed on a
non-layer cell sheet of the L strain cell cultivated in petri dishes. After each test piece was taken out from the dish at the 96 hour of cultivation, the cells were fixed and stained to observe their morphological change and to count the number of cells around the test piece. As is shown in Fig. 6, almost all the cells under the test piece of cobalt-chromium and PMMA resin degenerated and disintegrated. On the contrary, almost all cells under the TRUTISSU test piece maintained their bioactivities showing normal cell mitosis. This may be caused by a sufficient supply of nutritional requirements through the pore of TRUTISSU. Normal cell mitosis was observed on the SUS-316 filament of TRUTISSU by SEM (Fig. 7), and the normal cells were closely adhered to the surface of the filament. The living condition of mucous membrane under the TRUTISSU plate may be kept normal unlike in the conventional dentures\textsuperscript{16}.

**Contamination**

Because of the porous structure, the TRUTISSU dentures tend to have food impaction in the pores, and the impaction obstructs permeation of oral fluid. Therefore the loss of the original function of TRUTISSU as well as microbial contamination was concerned\textsuperscript{17}. However, the patients could use them without any medical trouble. This means that pores

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**Fig. 6** Cell growth right under the test plate. No cell growth under the cobalt-chromium cast plate and resin plate, normal cell growth under the TRUTISSU plate.

**Fig. 7** Cells are adhered closely to the surface of metal wire of TRUTISSU and show normal cell form.
are filled with saliva when the denture is worn in the mouth. Through biting and swallowing movements, impacted solid food could be removed. In other words negative and positive pressures in turn allow the solid food ingredients in the pores to pass through, so that microbial contamination in pores may be prevented. However, possible generation of microbial flora should be observed as an important problem for this material.

The test pieces of cobalt-chromium alloy, PMMA resin, and TRUTISSU were made into discs 8 mm in diameter with 0.4 mm thickness, and set on the palatal mucous membrane of 5 dentists including us. The test piece was taken out of the mouth 24 hours after setting, and the test piece was immersed and vibrated in a cleansing solution of a natural detergent for 1 minute, rinsed with water and placed on the agar plate of cultivation medium. The bacterial growth rate was scored into four classes, as shown in Table 2. While marked bacterial growth was observed in the pieces not cleansed, it was eliminated by the cleansing for only one minute. Though the cleansing may be a way to overcome the bacterial contamination, the problem of pore obstruction has not yet been solved. Therefore the cleansing method for food impaction into pores must be considered. However, from the results of clinical observation on 20 patients for 3 years, no inflammatory response was recognized during the clinical use of TRUTISSU denture.

**Observation of Clinical Application**

Maxillary full dentures of 30 patients were monitored for three years by 11 dentists. To observe the 14 items shown in Fig. 8, eleven dentists were cordially asked to be monitors for clinical evaluation of TRUTISSU dentures. For the purpose of the statistical process, observations were recorded in five grades, 5: very good, 4: good, 3: fair, 2: poor, and 1: very poor. Observation was made every 7 or 10 days.

To understand the chronological change of the indices on the TRUTISSU dentures, the index of the final day was compared with that of the initial insertion of the dentures. The change was shown with the inclination bar in Fig. 8. As a control, cobalt-chromium dentures of the same design were made and worn in turn with the TRUTISSU denture for three days.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>NO CLEANSING</th>
<th>CLEANSING WATER</th>
<th>AGENT(1)</th>
<th>AGENT(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-Cr cast plate(P)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Co-Cr cast plate(R)</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Resin plate</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TRUTISSU</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Ranking of bacterial growth ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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</tbody>
</table>
For comparison, the index of the cobalt-chromium denture was constantly fixed to 3.

The indices of the TRUTISSU dentures are equivalent or slightly superior compared with those of the cobalt-chromium denture. The clinical conditions are not thoroughly explained by such numerical expression. Some interesting clinical observations are given below.

Some patients had the unusual tactile sense on their tongue immediately after changing their previous cobalt-chromium dentures to the new TRUTISSU dentures, due to the surface roughness. However, they become accustomed to it after several hours. Regarding the sense of temperature and gustation, the TRUTISSU denture was quite superior to conventional dentures of the solid plate. This is obviously the merit of porous material.

The sense of taste or flavor on food and drink was particularly excellent. Sweet taste and acid taste, etc. seem to remain somewhat longer, but this was evaluated in the positive or negative, depending on the preference of individual patients. All patients noted the lighter weight of the TRUTISSU dentures. However the TRUTISSU dentures are only 12-13% lighter than the cobalt-chromium dentures and 10% heavier than the resin dentures. The reason the patients felt TRUTISSU dentures lighter than the resin dentures, must be related to sense factors involved in the whole oral system, but they are not known. The TRUTISSU dentures may have a different mechanism of retention power.

Dryness and feeling of re-insertion were equivalent to other dentures. The patients pointed out that the TRUTISSU denture was better than conventional dentures.

CONCLUSION

A new porous plate of denture base material, TRUTISSU consisting of a metal mesh was developed to minimize the harmful effect of conventional dentures upon the tissue of mucous
membrane and to maintain the normal physiological conditions of biting, pronunciation, gustation, temperature sense, and tactile sense, etc. Under the denture plate, the following findings were obtained from in vitro experiments and clinical observations by monitoring on 30 patients.

1) Though fitness of the TRUTISSU plate was quite satisfactory to the master model due to the precision of the swaging method with a high dimensional accuracy in the trial wax denture, the large space produced at the posterior margin after the polymerization, because of the thermal change and polymerizing shrinkage of the alveolar part of the resin during heat polymerization. Such deformation was also found in dentures of cobalt-chromium and PMMA resin. TRUTISSU and cobalt-chromium dentures could easily bring satisfactory fitness by sectioning the alveolar part of the resin at the interproximal areas of the cuspids and premolars, due to the release of the residual stress. However no improvement was made in the resin denture. This phenomenon is serious enough to negate fitness and occlusal relation obtained on trial wax dentures.

2) Regarding the retention of suction and adhesion in TRUTISSU dentures to mucous membrane, in vitro experiments using artificial mucous membrane of agar plate and artificial saliva showed equivalent results to conventional solid dentures, so that no problem in clinical use was noted.

3) In vitro tests on biocompatibility, the living cells showed favourable adhesion to the surface of TRUTISSU metal wires. The cells showed a normal shape without any degeneration. A monolayer cell sheet right under the test piece of TRUTISSU plate also maintained normal growth, which seem to prove that nutritional requirements of the cells were satisfied through pores of the TRUTISSU plate. This suggested that the mucous membrane could be kept healthy dentures under the dentures successfully in clinical cases.

4) In comparison with cobalt-chromium dentures, the sense aspects were much superior in TRUTISSU dentures. Wearing comfort, temperature sense, gustation and flavor of food were more favourable, which is an obvious advantage of TRUTISSU denture over other conventional dentures.

5) Bacterial contamination of TRUTISSU dentures could be eliminated by the use of a neutral cleansing agent, but the food obstruction in pores must be solved in future.

In conclusion, in in-vitro experiments and clinical observations show that TRUTISSU is a very interesting and effective material for denture base.

Grateful acknowledgement is made to Professor M. Nishiura and Assistant Professor Y. Gonda, the First Department of Prosthetics, Osaka Dental University, and Dr. M. Shintani, who have so generously given valuable advices from the prosthetic viewpoints in clinical application of TRUTISSU. Acknowledgements also go to Dr. F. Komuro, Dr. T. Sasaki, Dr. T. Higuchi, Dr. T. Nakamura, Dr. T. Kataoka, Dr. T. Sawada and Dr. K. Nishimura for their kind advices and helps in clinical aspects. Many thanks to President, H. Wada and Manager, T. Tsutsumi, Wada Seimitsu Shiken Inc. for their grateful cooperation and Ms. Y. Ohta for her assistance.

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表面滑沢硬化処理床用レジンの耐摩耗性

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表面滑沢硬化処理した床用レジンの耐摩耗性を表面粗さRa, Rz, Rq及びプラシング消耗量の観点から検討した。すなわち、表面滑沢硬化処理剤、Linkle Coat (Coating 1)及びPermacure Link (Coating 2)の2種類を用いて、それら処理したものと無処理のものとのを統計的に比較、検討した。その結果、表面滑沢硬化処理した場合、その耐摩耗性は無処理のコントロールよりももより優れており、ときに、Coating 1による床用レジンの消耗量は摩耗回数の増加にもかかわらずCoating 2のものよりも少ないことが判明した。

金属メッシュブレートの義歯床への応用

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床義歯装着時におこなう床下粘膜組織にみられる異常をできるだけ軽減し、粘膜の生理機能を自然状態に保持できるような床用材料 TRUTISSU を試作し、いくつかの基礎実験を行なうとともにモニターによる臨床観察をも行ない、以下の数値的な評価が得られた。1. TRUTISSU の成形性はよく、成形後の適合性は良好であった。2. ロッキ状粘膜に対する細の吸着維持については他の材料とくらべて同等の維持力が示された。3. 生物学的適合性については TRUTISSU の構成金属系上に対して良好な細胞の接着性を示し、何らの変性も認められなかった。また、口蓋粘膜をシミュレートした人工粘膜上の細胞について TRUTISSU 直下の細胞は正常な増殖を示した。4. コバルト・クロム床やレジン床との比較について、装着感、温度感および好品に対する味覚などに
ついて高い評価が得られ他の実用材料にはみられない特長が示された。以上、いくつかの基礎実験と臨床観察の結果を考え合わせると、今後さらに改良すべきいくつかの点を残しているとはいえ TRUTISSU は実用材料として有用な材料であることが理解できた。

コンポジット型接着力オペクレジンに関する研究

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コンポジット型接着力オペクレジンの諸性質を検討した。このレジンと同種合金どうしを接着した場合、Sn電析処理をした Type IV 金合金や金銀パラジウム合金、およびサンドブラスト処理したステンレス鋼などのいずれの接着耐久性を示した。一方、このレジンで硬質レジンと合金を接着する場合は、操作性に改善の余地が認められた。その他、光重合型歯冠用硬質レジンの物性に対して、熱と照合時間が影響を及ぼしていることが明らかとなった。

クラウン・ブリッジ用および衆材焼付用 Ni-Cr
合金焼造体に及ぼす鉄造機の影響——(第 1 報) 引張強さの変化——

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市販のクラウン・ブリッジ用および衆材焼付用 Ni-Cr合金 9 種類を、5 種類の歯科用焼造機を用いて溶融・焼造し、焼造機による焼造体の引張強さの差異を調べた。また貴金属系合金 2 種類を 3 種類の焼造機により溶融・焼造し、Ni-Cr 合金の場合と比較した。

Ni-Cr 合金の引張強さには貴金属系合金の場合に比べて、使用した焼造機が大きく影響を与えていた。この影響は Ni-Cr 合金のタイプ別、さらに同じタイプでも合金ごとに異なっており、特に、クラウン・ブリッジ用合金では著しい引張強さの変化が認められた。本実験に用いた焼造機の中で、クラウン・ブリッジ用 Ni-Cr 合金にはアルゴンキャスター（アルゴンガス雰囲気溶融 + 真空加圧焼造）が、一方衆材焼付用 Ni-Cr 合金にはダイナー（大気中アルゴンガス吹付けアーク溶融 + 遠心焼造）あるいはキャストマチック（アルゴンガス雰囲気アーク溶融 + 吸引加圧焼造）が、引張強さの高い焼造体を与える傾向にあった。

EVA-MMA-TBBO 接着性コンポジット材料の根管充填剤としての評価

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****東京医科歯科大学医療器研究所有機材料部門

EVA-MMA, AH26, Super bond, 酸化亜鉛酵ュージーノールを用いて透過性検査を行ない、根管封鎖性を評価した。EVA-MMA, AH26, Super bond は酸化亜鉛酵ュージーノールより封鎖性が良かった。EVA コンポジットは根管壁適合に対し最も良好な性質を示した。EVA-MMA, KP-MMA, ハイドロキシアパタイト (HAP) をサルの抜歯窩にインプラントする系と EVA-MMA, KP-MMA, PMMA をラットの皮下にインプラントする系