In vitro Adherence of Microorganisms to Denture Base Resin with Different Surface Texture

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We examined the effects of various denture base resin surface textures on the adherence of microorganisms. S. sanguis and B. gingivalis adhered in greater amounts to the denture base resin than the other microorganisms tested. As to bacterial adherence according to polishing state, S. oralis, B. gingivalis C-101, and B. intermedius C-001 more adhered to the No. 400 paper-polished surface than to the buff-polished and smoothening-treated surfaces. S. sanguis less adhered to the smoothening-treated surface. S. mitis and C. albicans, on the other hand, more adhered to the smoothening-treated surface. For the other microorganisms tested, no relationship was observed between surface texture and bacterial adherence. The fall-off test revealed no remarkable differences in the fall-off of S. sanguis and B. gingivalis C-101 by the types of surface treatment. However, the fall-off of C. albicans was poorest from the No. 400 paper-polished surface. These results indicate that smoothening the denture base surface is important for denture plaque control.

Key words: Denture base resin, Surface texture, Bacterial adherence

INTRODUCTION

It has been reported that microorganisms inhabiting denture plaque, in particular the Candida species, play a role in the development of denture stomatitis1-4). Thus adherence of Candida to denture base resin has been studied by a number of researchers5-11). Since caries and periodontitis of abutment teeth are likely to develop after inserting a partial denture, examining the adherence of pathogenic bacteria is essential10).

After inserting a denture, its surface changes, and these changes promote the adherence of denture plaque12). There are few reports, however, on the relationship between the surface texture of the denture base resin and the adherence of denture plaque13).

In this study we examined the effects of various base resin surface textures on the adherent ability of microorganisms which cause caries, periodontitis and denture stomatitis.

MATERIALS AND METHODS

Specimens

Both sides of 10 mm × 10 mm × 1 mm square heat-cured denture base resin plates were

* Acron, GC Dental Industrial Corp., Tokyo, Japan
treated in one of the following three ways: polishing with emery paper No. 400\footnote{Nippon Coated Abrasive, Aichi, Japan}; polishing with emery paper No. 2000\footnote{Perma cure system, GC Dental Industrial Corp., Tokyo, Japan} and subsequent buff polishing; or polishing with emery paper No. 2000 followed by surface smoothening treatment\footnote{Gaspack, BBL, London, England}. The mean roughness (Ra) of the No. 400 paper-polished resin, buff-polished resin, and surface-smoothening-treated resin were 1.12 µm, 0.09 µm, and 0.22 µm respectively. The contact angles of distilled water on No. 400 paper-polished resin, buff-polished resin, and surface-smoothening-treated resin were 68.9, 67.6, and 60.9 degrees respectively. All specimens were examined after immersion in 37°C water for 7 days.

Microorganism culture and labeling

Streptococcus mutans ATCC 25175, Streptococcus sanguis ATCC 10556, Streptococcus oralis ATCC 35037, Streptococcus mitis ATCC 33399, Streptococcus salivarius ATCC 25975, Bacteroides gingivalis ATCC 33277, Bacteroides gingivalis C-101 (Clinical), Bacteroides intermedius ATCC 15032, Bacteroides intermedius C-001 (Clinical), and Candida albicans IFO1060 were used in these experiments.

A 0.1 ml aliquot of a *C. albicans* suspension was inoculated to 20 ml of Sabouraud glucose broth\footnote{Nissui, Tokyo, Japan} containing 5 µCi/ml [6-3H]-glucose\footnote{TRK-85, Amersham International plc, Buckinghamshire, England}. The broth was then incubated at 37°C for 24 hours under aerobic conditions. Other bacteria were added to 20 ml of trypticase soy broth\footnote{BBL, London, England} with 0.5% yeast extract\footnote{Difco, Laboratories, Detroit, Michigan, U. S. A} containing 2 µCi/ml [6-3H]-thymidine\footnote{TRK-61, Amersham International plc, Buckinghamshire, England}, and incubated in anaerobic jar\footnote{Gaspack, BBL, London, England} at 37°C for 24 hours. The suspensions were centrifuged at 8,000 G for 20 min and radiotagged cells were washed gently two successive portions of pH 7.0 phosphate buffer solution.

Adherence of bacteria

According to the Ørstavik et al.\footnote{ASC-113, Aloka, Tokyo, Japan} method, specimens were coated with saliva in a water bath incubator at 37°C for 2 hours. Subsequently each specimen was immersed in 1 ml of the radiotagged cell suspension (10⁶ cells/ml) and then gently shaken at 37°C for 2 hours. Specimens were then washed gently with two successive portions of pH 7.0 phosphate buffer solution and then incinerated in an automatic sample combustion system\footnote{LSC-903SP, Aloka, Tokyo, Japan}. The amount of adherent bacteria was determined by measuring [6-3H]-radioactivity (DPM) with a liquid scintillation counter\footnote{LSC-903SP, Aloka, Tokyo, Japan}. Data were analyzed by one-way analysis of variance for each microorganisms.

Fall-off test

While ultrasonically treating a piece of denture base resin with adhered *S. sanguis*, *B. gingivalis* C-101, and *C. albicans* for 1 min, the rate of bacteria fall-off was examined.
RESULTS

Adherence of microorganisms

Table 1 shows the adherence of microorganisms to the surfaces of resins treated in each of the three ways. S. sanguis, B. gingivalis ATCC, and B. gingivalis C-101 adhered in greater amounts to each of the polishing surfaces than the other microorganism. As to bacterial adherence among the surface texture, S. oralis, B. gingivalis C-101, and B. intermedius C-001 more adhered to the No. 400 paper-polished surface. S. sanguis less adhered to the smoothing-treated surface. S. mitis and C. albicans, on the other hand, more adhered to the smoothing-treated surface than to the other polished surfaces. No relationship was found between surface treatment and adherence of S. mutans ATCC, S. salivarius, B. gingivalis ATCC, and B. intermedius ATCC.

Fall-off test

For S. sanguis and B. gingivalis C-101, we found no remarkable difference between the polishing state and the fall-off rate. However, the fall-off of C. albicans was poorest from the No. 400 paper-polished surface (Table 2).

Table 1  Bacterial adherence on denture base resin under each polishing condition

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Polishing condition of resin surface (DPM)</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Buff polishing</td>
<td>Emery paper polishing</td>
<td>Surface smoothening</td>
<td></td>
</tr>
<tr>
<td>S. mutans ATCC 25175</td>
<td>602*</td>
<td>324</td>
<td>463</td>
<td></td>
</tr>
<tr>
<td>S. sanguis ATCC 10556</td>
<td>10435</td>
<td>9041</td>
<td>4646</td>
<td></td>
</tr>
<tr>
<td>S. oralis ATCC 35037</td>
<td>444</td>
<td>488</td>
<td>176</td>
<td></td>
</tr>
<tr>
<td>S. mitis ATCC 33399</td>
<td>388</td>
<td>642</td>
<td>1005</td>
<td></td>
</tr>
<tr>
<td>S. salivarius ATCC 25975</td>
<td>860</td>
<td>687</td>
<td>750</td>
<td></td>
</tr>
<tr>
<td>B. gingivalis ATCC 33277</td>
<td>5111</td>
<td>5483</td>
<td>6236</td>
<td></td>
</tr>
<tr>
<td>B. gingivalis C-101</td>
<td>962</td>
<td>11950</td>
<td>9804</td>
<td></td>
</tr>
<tr>
<td>B. intermedius ATCC 15032</td>
<td>708</td>
<td>297</td>
<td>383</td>
<td></td>
</tr>
<tr>
<td>B. intermedius C-001</td>
<td>380</td>
<td>848</td>
<td>428</td>
<td></td>
</tr>
<tr>
<td>C. albicans IFO 1060</td>
<td>24</td>
<td>42</td>
<td>136</td>
<td></td>
</tr>
</tbody>
</table>

*: Mean value of three specimens

Table 2  Fall-off rate of bacteria from denture base resin under each polishing condition by ultrasonic treatment

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Fall-off rate</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Buff polishing</td>
<td>Emery paper polishing</td>
<td>Surface smoothening</td>
</tr>
<tr>
<td>S. sanguis ATCC 10556</td>
<td>69.5*</td>
<td>88.8</td>
<td>77.9</td>
</tr>
<tr>
<td>B. gingivalis C-101</td>
<td>79.4</td>
<td>77.8</td>
<td>86.7</td>
</tr>
<tr>
<td>C. albicans IFO 1060</td>
<td>45.9</td>
<td>26.9</td>
<td>49.7</td>
</tr>
</tbody>
</table>

*: \((1 - \frac{\text{DPM after ultrasonic treatment}}{\text{DPM before ultrasonic treatment}}) \times 100\), mean value of three specimens
DISCUSSION

In this study, *S. oralis*, *B. gingivalis* C-101, and *B. intermedius* C-001 adhered to the No. 400 paper-polished surface, which had the largest surface roughness value. These results suggest that care should be taken in polishing and plaque control for resin adjacent to the abutment teeth of a partial denture, otherwise caries and periodontitis near abutment teeth may be accelerated. Badawi *et al.*\(^{13}\) reported that plaque adherence is significantly greater on unpolished fitting surfaces of upper complete dentures than on polished surfaces. Therefore, increased surface roughness can lead to problems.

Satou *et al.*\(^{15}\) found that the contact angles of restoratives and the adherent cells showed high positive correlation for *S. sanguis*. Minagi *et al.*\(^{9}\) showed that adherence of *Candidas* increases when the surface free energy of the resin calculated by the contact angle is equivalent to that of *Candidas*. In the present study there was no relationship between contact angle and bacterial adherence except for *S. sanguis*, *S. oralis*, *S. mitis*, *B. gingivalis* C-101, *B. intermedius* C-001 and *C. albicans*; this may be explained by the lack of any remarkable difference in contact angles among the various polished surfaces and difference of hydrophobicity of each microorganism.

*C. albicans*, pathogenic microorganisms of denture stomatitis, lowest adhered to the resin surface than the other microorganisms; however, *C. albicans* more adhered to the surface-smoothening-treated resin than to the other polished resins. Minagi *et al.*\(^{9}\) reported that *C. albicans* is strong hydrophobic bacteria, and best adhered to the hydrophobic materials. Because surface-smoothening-treated resin has smaller contact angle than the other polished resins, namely, it is more hydrophobic than the other polished resins, *C. albicans* more adhered to the surface-smoothening-treated resin than the other polished resins.

Budtz-Jørgensen *et al.*\(^{16}\) inserted the complete dentures in which half of fitting surface is treated with surface-smoothening and remaining is not treated, and monitored plaque accumulation on fitting surfaces, the number of bacterial colonies, and the proliferation of yeast after 1 week and 1 month. At 1 week all treated surface values were significantly smaller than the non-treated surface values, whereas after 1 month no differences were observed. There are several probable explanations for disagreement with our results that *C. albicans* well adhered to the surface-smoothening-treated resin than buff-polished resin. Firstly, they studied only fitting surface which had different environments for plaque accumulation and anaerobically. The period of exposure to microorganisms was far shorter in our experiments since we wanted to study early adherence events. Lastly, denture base resins were coated with pellicle in their experiment.

In the fall-off test, *S. sanguis* and *B. gingivalis* C-101 were used because they adhered in greater amounts to the resin surface than the other microorganisms, and these microorganisms induce caries or periodontitis. Also, *C. albicans* was used as an example of a pathogenic bacteria of denture stomatitis. The polishing state of the denture base resin did not influence the fall-off rate of *S. sanguis* and *B. gingivalis* C-101. The fall-off rate of *C. albicans* was equivalent on the surface-smoothening-treated and the buff-polished resins. Based on these observations, surface smoothening-treatment appears to be the effective for removal of bacteria from the surface of denture base resin. Budtz-Jørgensen *et al.*\(^{16}\) stated that plaque...
adhered to smoothening-treated surfaces is easily removed. We confirmed that plaque is readily removed from the surface of smoothening-treated dentures\textsuperscript{17).}

These results indicate the importance of polishing the denture base surface to minimize adherence of microorganisms.

**CONCLUSIONS**

The effects of the denture surface texture on the adherence of oral microorganisms were studied using *Streptococci, Bacteroides*, and *Candida albicans* as test microorganisms. Their adherence to and release from resin surfaces treated with either No. 400 emery paper-polishing, buff-polishing, or surface-smoothening was examined.

*S. sanguis*, *B. gingivalis* ATCC, and *B. gingivalis* C-101 adhered in greater amounts to the denture base resin than the other microorganisms tested. As to bacterial adherence among the polishing conditions, *S. oralis*, *B. gingivalis* C-101, and *B. intermedius* C-001 more adhered to the No. 400 paper-polished surface. *S. sanguis* less adhered to the smoothening-treated surface. On the other hand, *S. mitis* and *C. albicans* more adhered to the smoothening-treated surface than to the other polished surfaces. In *S. mutans*, *S. salivarius*, *B. gingivalis* ATCC, and *B. intermedius* ATCC, no correlation was observed between surface texture and bacterial adherence.

The fall-off rate of *S. sanguis*, *B. gingivalis* C-101 and *C. albicans* from variously treated resin surfaces by ultrasonication was examined. In *S. sanguis* and *B. gingivalis* C101, no remarkable differences were noted among the surface treatments. However, the fall-off rate of *C. albicans* was poorest on the No. 400 paper-polished surface.

**REFERENCES**

本号掲載論文の和文抄録

マイクロ波照射下での連続温度測定
P. F. Hogan and T. Mori
シドニー大学歯学部歯科補綴学教室

マイクロ波による義歯作製法を検討する一手段として、マイクロ波照射下での連続温度測定を試みた。クロメルアルメル熱電対をインサート細管中に封入することにより、熱電対への電磁波障害を除去することができた。

プラスコ内の水（50 ml）の温度上昇を500 Wと50 Wの条件下で測定し、水銀温度計による測定の結果と比較した。500 Wでは、水の沸騰は1分以内に観察されたが、熱電対法により、約45秒に100℃に達していることが明らかとなった。50 Wでは、3秒間のマイクロ波照射が32秒の周期で起こり、加熱開始後約6分に100℃を記録したが、これは短時間の照射のため肉眼観察や水銀温度計ではとらえられず、水の沸騰が観察されたのは、加熱開始後約10分であった。

各種メタクリレートの10%クエン酸－3%塩化第二鉄溶液処理象牙質への
接着性に及ぼす水の影響について
福島忠男，堀部 隆
福岡歯科大学歯科理工学教室

各種メタクリレートの10%クエン酸－3%塩化第二鉄溶液処理象牙質への接着性に及ぼす水の影響について検討するために、2 mol%の親水性モノマー（HEMA、3 MPA）および酸性モノマー（PyIEM、NEM）を含む4種のMMA-TBB系レジンを調製し、水中浸漬1日、1ヶ月、6ヶ月、1年後に30秒間10－3処理した牛歯象牙質への接着力を測定した。さらに、モノマーの構造と接着力の関係を検討した。
モノマーの構造と接着力の関係はいずれの条件でも顕著に認められなかったが、1年後の接着力はいずれも著しく減少していた。

1日間水中浸漬した試料の接着力測定後の破壊パターンは、主にレジンやデンシナーの凝集破壊であったが、1年水中浸漬した試料の場合は、接着界面の剥離や樹脂含浸層の破壊が多く認められた。

従って、接着力の減少は、主に水による樹脂含浸層のコラーゲンの脆化や樹脂含浸層内外のレンジの劣化の差に基づくものと考えられる。

In vitroにおける異なる表面性状の床用レジンへの細菌付着について
山内六男，山本宏治*，若林 学*，川野聡二
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*朝日大学歯学部歯科保存学第1講座

エメリペーパー400番研磨、バフ研磨および表面滑沢硬化処理を行った床用レジンへの Streptococci，Black-pigmented Bacteroides および Candida albicans の付着について検討した。
S. sanguis および B. gingivalis は、他の供試菌に比べて
床用レジンへよく付着していた。床用レジンの表面性状
別にみた場合、S. oralis, B. gingivalis C-101 および B.
intermedius C-001 は、表面粗さの最も大きい400番研
磨面への付着が表面粗さの小さい1番研磨面および表面
滑沢硬化処理面よりも多く、S. sanguis では表面滑沢
硬化処理面への付着が少なかった。S. mitis および C. al-
bacans では表面滑沢硬化処理面への付着が多かった。そ
の他の供試菌では、表面粗さと細菌付着との間に有意な
関連はみられなかった。
一方、S. sanguis, B. gingivalis C-101 および C.
albicans の各研磨面からの脱離性についてみた場合、C.
albicans はアミリペーパー 400 番研磨面からの脱離率が
悪かった。これらの結果から、デンチャー・ブラックに
とっては、義歯床表面を滑沢化することが必要であると
いう示唆された。

ディボンディング時のレジンの歯面残留の
抑制を目指した新しい金属製ブラケット

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*奈良県立医科大学口腔外科学講座
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***大阪大学歯学部歯科理工学講座

矯正用ブラケットのディボンディング時にはレジンが
歯面に残留しないことが望ましい。これを目的として新し
い金属製ブラケットを試作し、その基本的特性について
検討した。ブラケットはステンレス製で基本的な外形は
直径3.8 mm, 高さ1.8 mmの円筒形である。ツインタイ
プのウイングと0.018 inch (0.457 mm) のスロットを有
しており、レジンはベース辺縁の小さな折り込み形態に
よって保持される。3種類の代表的なレジンを用いて、
ブラケット-レジン間における単純引張り強さを測定し
たところ、平均80 kgf/cm²以上の強さを有していた。ヒ
ト抜去歯におけるディボンティングでは、paste-paste
type の heavily filled resin ではレジンの歯面残留はほ
とんどみられなかった。これらの結果から、この新しい
ブラケットに適したレジンを選択した場合には、十分な
接着強さを有しながら、ディボンディング時のレジンの
歯面残留が極めて効果的に抑制されることが示された。

2-ヒドロキシエチルメタクリレートの
水溶液中からの象牙質への吸着

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2-ヒドロキシエチルメタクリレート（HEMA）水溶
液のプライマー効果を検討するため、象牙質に対する吸
着を検討した。
HEMA の吸着には、次のような特徴が認められた。
（1）平衡到達が遅いこと（72 時間）。
（2）直線的な吸着等温線を描き、急激にプラトーを示
すこと。
（3）プラトーでは2.5 wt% の大きな吸着量であったこ
と。
（4）等温線のごく初期は垂直な傾きをもつこと。
象牙質粉末の表面には HEMA 吸着後にも形態的な変
化はなかったが、酸洗すると無吸着象牙質に比べて耐酸
性が向上した。また、吸着象牙質を SEM 観察すると、耐
酸性象牙質層の形成が認められた。
得られた結果を総合すると、HEMA は吸着中に象牙
質実質内に含浸するものと考えられた。