INFLUENCE OF SPRUE DESIGN ON SOUNDNESS OF RPD CASTING

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مقدمـــة

يلعب تصميم وتد الصب دوراً مهماً في عملية صب الخليطة المعدنية للأجهزة الثابتة أو المتحركة. وليقوم التعويض الجزئي المتحرك بوظيفته، يجب ألا يظهر أي عيوب أو نقص في بنية الهيكل، ومع ذلك تحوي العديد من هياكل التعويضات المتحركة عيوباً داخلية وخارجية مختلفة في الشكل والحجم والتي تسبب فشل التعويض، وقد درس عدد من الباحثين أثر التصاميم المختلفة لأوتاد الصب على مسامية مكونات التعويضات الجزئية الثابتة (الجسور) ولكن تأثير التصاميم المختلفة لأوتاد الصب على صلابة هيكل التعويضات الجزئية المتحركة لم يبحث بشكل واف.

لذا تبحث هذه الدراسة تأثير التصاميم المختلفة لوتد الصب على صلابة هيكل التعويض الجزئي المتحرك.

المواد والطرق

تم اختيار ثلاثة نماذج مختلفة من أوتاد الصب، وذلك لدراسة تأثيرها على صلابة الأجهزة المتحركة الجزئية.

النموذج الأول:

يشكل شجرة من الشمع مؤلفة من ٤ مكونات كل واحدة بقطر ٣ ملم تتجه مباشرة إلى أربعة مواضع مختلفة على محور الربط الرئيسي.

النموذج الثاني:

يشكل وتد حلقي من الشمع بقطر ٣ ملم، أما الأوتاد الثانوية (المساعدة) والتي تنشأ من المغذي الحلقي وعددها ستة أوتاد فتكون بقطر ٢ ملم ومرتبطة مباشرة مع الوصلة الرئيسية. يرتبط المغذي الحلقي بأسفل الوتد بواسطة أربعة أوتاد قطر كل منها ٣ ملم.

النموذج الثالث:

يشكل شجرة من أربع مكونات من الشمع بقطر ٣ ملم وكل شجرة تحتوي على حجرة تغذية بقطر ٥ ملم.

تم صب خمسة أجهزة متحركة جزئية لكل نموذج من النماذج الثلاثة، ولتحديد مدى انعدام المسامية من الهياكل المعدنية للتعويضات المتحركة الجزئية، تم اللجوء إلى طريقتين للتقييم.

١ ـ عيانياً بفحص كل هيكل بالرؤية المباشرة باستخدام مرآة مكبرة وتم فحص: الضمات الثلاث، الوصلة الرئيسية، ومنطقتي الشبك المعدني، من حيث المسامية أو أي نقص ضئيل في صب المعدن.

٢ ـ شعاعياً باستخدام الأفلام الإطباقية لتصوير الهياكل المعدنية، ودرست هذه الصور الشعاعية، والمتغيرات التي أخذت في عين الاعتبار إثنتان: (أ) نسق وتد الصب. (ب) طريقة الملاحظة.

النتائج

يوضح الجدول رقم ١ الدرجات التي أعطيت لكل من الضمات ـ الوصلات الرئيسية، والشبكات المعدنية، نتيجة الفحص المرئي (المشاهدة) للهياكل المعدنية الخمسة عشرة.

لوحظ عدم وجود عيوب مرئية في الضمات، وكانت العيوب في الوصلات الرئيسية ثمانية، ثلاثة منها في وصلة رئيسية واحدة. أما الشباك المعدنية فكانت العيوب فيها ثمانية وحدثت هذه العيوب جميعها عند استعمال نموذج وتد الصب الحلقي مع عيبين في هيكل معدني واحد.

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يوضح الجدول رقم ٢ الدرجات التي أعطيت للمكونات المدروسة بالفحص الشعاعي . لم يشاهد أية عيوب في الضميات . ثمانية عيوب شوهدت في الوصلات الرئيسية ، والثلاثة التي شوهدت في الفحص المرئي شوهدت شعاعياً أيضاً العيوب في الشبكة المثبتة كانت ٢١ عيباً ، إحدى الشبكات المعدنية التي ظهرت بالفحص المرئي (العياني) عيبان فقط ، أظهر الفحص الشعاعي وجود ٥ عيوب فيها من نواح أخرى كان الفحص المرئي والشعاعي متطابقان .

يوضح الجدول رقم ٣ عدد العيوب الناشئة عن تفاعل العوامل المختلفة (طريقة وضع وتد الصب ، طريقة المشاهدة ، والمنطقة المفحوصة) .

الاستنتاج

قادت نتائج هذه الدراسة إلى أن النماذج الثلاثة من أوتاد الصب مناسبة لإعطاء قاعدة جهاز متحرك جزئي صلبة ، مع الإشارة إلى أنه في النموذج الحلقي لابد من إعطاء بعض الثخانة للشبكة المعدنية المتصلة بمحور الربط الرئيسي .

Three different sprue designs were investigated visually and radiographically to determine the influence of spruing arrangement on the soundness of RPD castings. The first sprue design was a tree sprue design consisted of four wax formers, 3 mm in diameter each, going directly to four different spots *on* the major connector. The second sprue design was a circular sprue design. The circular feeder was made from a 3 mm diameter wax. The auxiliary sprues emanating from the circular feeder were six in number, 2 mm in diameter each, and were attached directly to the major connector. The circular feeder was attached to the sprue button by four formers, 3 mm in diameter each. The third sprue design was designated as the bali sprue design. The ball design consisted of four feeders, 3 mm in diameter each, as with the tree design except that a 5 mm ball reservoir was placed on each feeder, 5 mm away from the wax pattern. Five frameworks of the same dental cast were prepared using each sprue design. The results showed that the three sprue designs used in this study are suitabie for producing sound RPD frame castings. When the circular sprue design is used, allowances should be made to assure adequate meshwork thickness.

Introduction

Sprue design plays a major role in casting any type of alloy for fixed and removable prosthesis. Preston and Berger[1] stated that "spruing is an art which is not understood carefully". Many researchers examined the effect of different sprue designs on the porosity of fixed partial denture components.[2-4] However, the influence of sprue design on soundness of RPD frameworks was not adequately investigated.

A removable *partial denture* (RPD) framework should be free from defects within its structure in order to fulfill its function. Yet, many RPD castings contain internal and external defects of varying size and shape which can cause failure of the prosthesis[5] or result in an inferior appliance.[6]

Defects such as fissures and microporosities with surface connections may result in increased corrosion of the alloy.[7] Large pores or many porosities when situated in critical regions of the RPD frame may promote fracture.[8] The presence of defects *in* RPD castings is said *to* depend *on many* factors including the spruing method and the metal feeding direction. Evaluation of such defects can be achieved both visually and radiographically. Faults in a dental casting can result from one or more elements such as spruing,[9-15] investing,[16] casting,[10,16,20] alloy melting,[9,11,12,16] wax elimination,[10,16-20] and freezing of casting.[9] Dental technicians have the habit of ignoring the effect of sprue design on the casting by producing different designs which may affect the quality of castings. This study investigated the effect of various sprue designs on soundness of RPD castings.

Materials and Methods

A dental cast representing Kennedy Class I Modification I Removable Partial Denture (RPD) was chosen to serve as the master cast. The RPD framework design was decided utilizing three terminal abutments, teeth # 13 with a ledge resl and # 16 and # 24 with mesial rests. Circumferential clasps with retention bucaiiy and reciprocal arms lingually were designed on teeth # 16 and # 24. The RPD clasp with mid-buccal retention was designed on tooth # 13. Proximal plates were placed on the mesial of # 16 and distals of # 13 and # 24. Anterior and posterior palatal strap was chosen as the major connector. Undercuts on the master cast were blocked out. The cast was relieved, and external and internal finish lines were established. The master cast was then duplicated using Perplex* duplicating material to produce 15 identical refractory casts. The casts were divided to three groups. Each group of five casts were sprued with a different spruing arrangement using pre-formed wax**. Three different sprue design arrangements were tested.

The first spruing arrangement was designated as the tree sprue design. A tree sprue design consisted of four wax formers, each 3mm in diameter, going directly to four different spots on the major connector.

The second spruing arrangement was designated as the circular sprue design of which circular feeder was made from a 3mm diameter wax. Auxiliary sprues emanating from the circular feeder were six, each was 2mm in diameter and were attached directly to the major connector. The circular feeder was attached to the sprue button by four sprues, each 3mm in diameter.

The third sprue design was designated as the ball sprue design which consisted of four feeders, 3mm in diameter as with the tree sprue design except that a 5mm ball reservoir was placed on each feeder at 5mm away from the wax pattern.

Five refractory casts were thus sprued by one of each of the three spruing arrangements. All wax patterns were invested using the same batch of Wirovest*** investment material. Refractory casts were left to bench set for two hours before burnout.

A two-stage burn-out cycle was employed whereas the investment block was placed in a room temperature oven with the sprue base resting on the muffle floor. The oven was heated to 300°C and maintained at that temperature for 30 minutes. The ring was then rotated so that the sprue base is facing upward and the oven temperature was raised to 975°C in 3.5 hours. The investment was then heat soaked at 975°C for 45 minutes before it became ready for casting.

* Perplex (batch # 056022), Austenal Dental Product, Chicago, IL, USA.
** Bego pre-formed wax, Bego-Postfach 419220, D-2800 Bremen 41, West Germany.
*** Bego batch # 51050, Bego-Postfach 419220, D-2800 Bremen 41, West Germany.

A centrifugal induction casting machine* was used and the metal was cast at 1200°C using Wironit** cobalt-chromium alloy. The centrifugal force used was 9 bars and is the same as is used with clinical RPD castings in the laboratories at King Saud University College of Dentistry. All RPD frameworks were cast using a full metal charge of 25-35 gms. Variation in weight of the casting metal was due to differences in spruing arrangement and size. The appropriate weight for each spruing arrangement was determined experimentally in a pilot study.

After recovering the castings from the investment, they were blasted with 50 micron aluminum oxide*** at 80 psi and were ultrasonicaliy cleaned. All 15 RPD frameworks were completed and void of any major deficiency. After photographing the cast RPD frameworks and marking each with a random number, all sprues were cut-off and all frameworks were finished and each was placed in an envelope carrying its random number. Examples of the laboratory procedure in producing the RPD frameworks are shown in Fig. 1 a and b. Two evaluation procedures were used to fully assess the absence of porosities from the cast RPD frameworks.

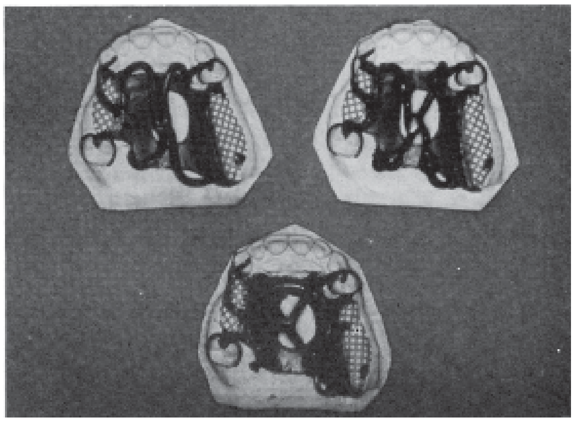

Figure la. RPD sprue design wax-up.

* Formax, model 35EM, Bego Postfach 419220, D-2800 Bremen 41, West Germany
** Bego batch # 50030, Bego-Postfach 419220, D-2800 Bremen 41, West Germany.
*** Korox 50 batch # 46062, Bego Postfach 419220, D-2800 Bremen 41, West Germany.

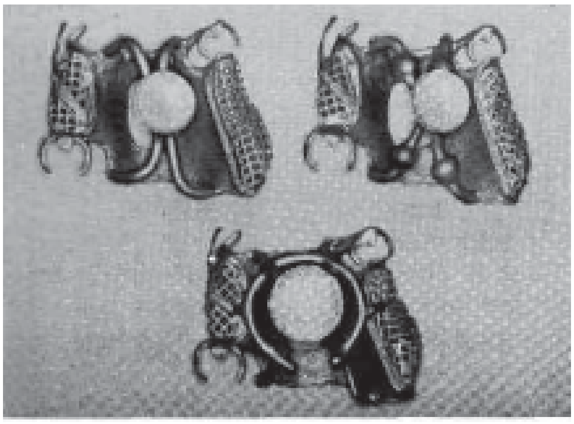

Figure 1b. Cast RPD frameworks.

1. Two clinicians examined each framework visually using a 5x magnification glass. Each clinician, working independently, used a special form made for this purpose and reported his findings to a third examiner. Each evaluator was asked to examine the 3 clasps, the major connector and the two meshwork areas for either a porosity or a small casting deficiency and report his findings as scores. Each component of each framework was scored from 0—3 or more based on the number of defects visible. No defects is a score of 0, one defect in a given component is a score of 1, two defects in a given component or one defect in each of two components of the same type (clasps or meshworks) is a score of 2, and so on.
2. Occlusal film radiographs* were taken on all frameworks (90kV[p] and 15mA). Each radiograph was placed in an envelope carrying a random number different from the visual examination random number. The radiographs were then evaluated and ranked by two clinicians independently. A 5x magnification glass and a light box were used to aid vision in evaluating the radiographs.

Several statistical analyses capable of delineating the influence of sprue design on the experimental outcome (porosity) can be used. Since there was no interest in the variation due to examiners the average values of the two scores were used. Thus, the only variables considered were two, the spruing arrangement[3] and the observation method.[2] Correlation matrix has been computed to show simple correlations between the variables. Multiple linear regression analysis has been conducted to observe the effect of spruing arrangement and that of the observation method. Analysis of variance has been computed.

* Heliodent 70-model, Siemens Medical Eng. Inc., Benshein, West Germany

Results

The visual rankings of clasps, major connectors and meshworks for the 15 frameworks are reported in Table 1. It was noted that there were no defects observed in any of the clasps. However, defects in major connectors were eight with as many as three (3) defects in one major connector. Defects in meshworks were eight (8), all of which occurred when a circular sprue arrangement was used with as many as two defects in one framework.

The radiographic rankings of the components examined are reported in Table 2. Again, there were no radiographic defects in any of the clasps. Defects in major connectors were 8. The three defects visually observed in one major connector were also seen radiographically. Defects in meshworks were 11. One of the meshwork that depicted two defects visually showed five defects radiographically. Otherwise, the visual and radiographic defects were identical.

Table 1. Visual defect ranking.

Clasps			Major Connector			Meshwork		
Tree	Circular	Ball	Tree	Circular	Ball	Tree	Circular	Ball
0	0	0	3	0	1	0	2	0
0	0	0	1	0	0	0	2	0
0	0	0	0	0	0	0	2	0
0	0	0	1	0	1	0	1	0
0	0	0	0	0	1	0	1	0

Table 2. Radiographic defect ranking.

Clasps			Major Connector			Meshwork		
Tree	Circular	Ball	Tree	Circular	Ball	Tree	Circular	Ball
0	0	0	3	0	1	0	5	0
0	0	0	1	0	0	0	2	0
0	0	0	0	0	0	0	2	0
0	0	0	1	0	1	0	1	0
0	0	0	0	0	1	0	1	0

Discussion

The number of defects as a function of factors (spruing method, observation method and area examined) is reported in Table 3. Descriptive statistics (mean, standard deviations) for defects as a function of the three factors are shown in Fig. 2. Table 4 shows that the spruing method and area examined have no significant influence on defect occurrence. However, the occurrence of defects was significantly influenced by the method of observation. In other words, clasps, major connectors and meshworks were not evenly influenced by changing the sprue design; rather they were affected differently. To detect which of the three areas was most affected by changing sprue design, the multiple range analysis reported in Table 5 was conducted. The analysis showed that clasps were not affected, however major connectors and meshwork were affected. While meshworks seemed more affected by sprue design than the major connector, homogeneity test showed no significant difference between them.

The fact that clasps were less subjective to casting defects when compared to meshwork areas is likely due to the difference in their cross-sectional areas. Defects in the major connector areas are likely due to the relatively large liquid metal volume in this area and its slower rate of solidification. When an area of the RPD frame remains liquified after the sprue feeders have solidified, this area becomes subjected to shrinkage porosity.

Table 3, Number of defects as a function of factors.

Factor	Count of Defect Levels	Readings	Means	Std. Error
Spruing				
method	Tree	30	.3333333	.1464785
	Circular	30	.5333333	.1495844
	Ball	30	.1333333	.0631243
Method of				
observation	Visual	*45*	.3333333	. 1054093
	Radiograph	45	.3333333	.105409
Area				
examined	Clasps Maj.	30	.0000000	.0000000
	connector	30	.4666667	.1495844
	Meshworks	30	.5333333	.1495844

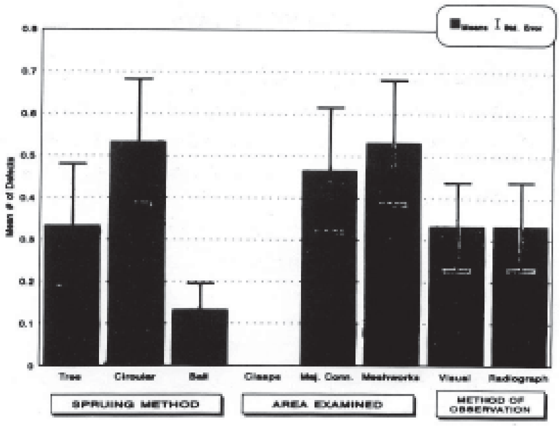

Figure 2, Number of defects as a function of factor considered.

Table 5. Multiple range *analysis* (95% LSD *intervals).*

Method Level	Count	Average	Homogenous groups
Clasp	30	.0000000	*
Major Connector	30	.4666667	*
Meshwork	30	.5333333	* *

Conclusion

Results and statistical analysis of this study conclude that any of the three sprue designs used in this study is suitable for producing sound RPD frame castings. When the circular sprue design is used, allowances should be made to assure adequate meshwork thickness.

Table 4. Three way anlysis of variance.

Source of Variation	Sum of Square	D.F.	Mean of Square	Calculated	Pvalue
Method of preparation	2.4000000	2	1.2000000	2.759	.0691
Area examined	.0000000	1	.0000000	.000	1.0000
Method of observation	5.0666667	2	2.5333333	5.825	.0043"

-* P 5=0.01

Acknowledgment

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