

Evaluation Of Subcutaneous Tissue Response To Implanted Samples Of Acrylic Resin Mixed With Metal Fillers

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Abstract

This study was conducted to study the subcutaneous tissue response as well as some properties of heat acrylic resin mixed with Aluminum (Al) and Silver (Ag). (2%;3%;5%;10%) concentrations of Al and Ag were added separately to heat cured acrylic resin and the mechanical properties of the mixture were examined by the common Elson technique. The addition of 2% of either Al and Ag to heat acrylic resin increased its transverse strength as well as its impact strength; while 5% and 10% concentrations reduced both the transverse and the impact strengths of the resin. Therefore 2% concentration was chosen for subcutaneous tissue implantation. Three pellets of acrylic resin one containing Al; one containing Ag and the third was free from both elements as a control were each implanted in the subcutaneous c.t. of twenty male albino rats. A thick connective tissue capsule surrounding each pellet was formed. Al containing acrylic resin was surrounded with a thicker capsule formed of collagen fibers infiltrated with many inflammatory cells; while the connective tissue reaction against the pure acrylic resin and Ag acrylic resin was minimal in the form of thin capsule formed of collagen fibers; fibroblasts and few inflammatory cells. Measurements of the capsule thickness and the number of inflammatory cells infiltrating the capsule showed a significant increase in Al group than in Ag and control groups. In conclusion the addition of 2% of either Al and Ag to heat acrylic resin improved its strength but Ag containing heat acrylic resin was more tolerable to tissue.

Introduction

Acrylic resins are the most widely used materials for denture base processing and also used in many surgical procedures because of the ease of manipulation; repair; pigmentation and insolubility in oral fluids (Omar and Shehata; 1993). Attempts have been made to improve the physical properties of acrylic resins and to overcome their drawbacks by adding different substances (Dixon et al; 1991). Adding metal fillers to dental base resin decreased the coefficient of thermal expansion (Sehajpal and Sood; 1989). Also it increased the impact and compressive strengths and decreased the wrap-

ability of the resin (Ragab; 1992). Biological compatibility of tissues to acrylic resins is quite essential because these materials have many uses including embedding within the tissue (A.D.A. 1982). Many investigators have used acrylic resins and found them harmless to living tissue (Hodosh et al., 1970). However others reported that biological changes of some resins was harmful and might induce tumours in laboratory animals (Habal and Powell; 1980). In this study we tried to examine the histological picture of the subcutaneous tissue response to Aluminum and silver containing acrylic resin in

concentrations that improve the physical properties of the resin .

Material And Methods

Two metal fillers were used in this study ; Silver and Aluminum in the form of pure metal powder . They were added to heat cured powder at 2% , 3% , 5% and 10% concentrations. 20 specimens were prepared for each concentration of silver and Aluminum . Another 20 specimens from the metal free acrylic resin were prepared as a control group. Specimens were prepared according to the American Dental Association (ADA) specification No. 15 and 12 for denture base polymers and subjected to transverse strength and impact strength tests by the standard Elson technique. Pellets of 2 x 4 mm diameter representing the three different group specimens were prepared. Histological study was carried on thirty male albino rats. Three midline abdominal skin incisions were made in each rat under general anaesthesia. The different pellets were implanted subcutaneously and the skin was closed using surgical thread .Five rats were anaesthetised weekly and the connective tissue surrounding different implanted pellets were dissected for four weeks and subjected for histological examination using the paraffin technique and suitable staining methods including Hx & E , toluidie blue and trichrome stains . Results were tabulated and analysed using the image analyzer and suitable statistical analysis tests for the results .

Results

Physical results

The addition of 2% and 3% of Silver and Aluminum fillers to the heat acrylic resin increased the transverse strength as well as the impact strength . These increase in mechanical properties

was found to be statistically significant . With higher concentrations of both metals both the transverse strength and the impact strength were reduced table (1&2) .

Histological results

Tissue sections of the connective tissue capsule surrounding the implanted pellets of metal free heat cured acrylic resin after two weeks showed that the formed capsule was very thin and formed of inflammatory cells mainly fibroblasts and collagen fibers fig .(1-A;B&C). Measurements of the capsule thickness showed that the mean diameter was $(40.374 \pm 3.7) \mu\text{m}$ fig (6) . In the first week the inflammatory cells were crowded and surrounded by congested blood vessels fig.(1-C) . The number of cells was gradually reduced. The mean number of cells in the capsule surrounding metal free control samples after four weeks was (200 ± 0.24) cell / fixed area fig .(5) .

Tissue sections of connective tissue capsule surrounding implanted pellets of heat cured acrylic resin containing 2% , 3% Silver metal filler after two weeks showed that the formed capsule was thin fig. (2-A). The capsule was formed mainly of fibroblasts and other infiltrating inflammatory cells including mast cells; macrophages and lymphocytes fig. (4-A&C). The number of cells was gradually decreasing. Measurements of the capsule thickness after four weeks showed that the mean diameter was $(122.082 \pm 16.6) \mu\text{m}$ fig (6) The mean cell number in the capsule surrounding Silver containing samples was (515 ± 0.46) cell /fixed area fig .(5) .

Tissue sections of the connective tissue capsule surrounding implanted pellets of heat acrylic resin containing 2% , 3 % Aluminum metal filler after two weeks showed that the formed capsule was the thickest and surrounded by many congested blood vessels . The

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capsule was formed of dense inflammatory cells including fibroblasts mast cells , macrophages and lymphocytes . The number of cells was gradually decreasing but a large number persisted up to the fourth week . The mean cell number was (650 ± 0.69) cell /fixed area fig.(5) and the mean diameter of the capsule was (190.550 ± 3.9) umfig.(6).

The mean diameters of connective tissue capsules in Aluminum and Silver groups were higher than that in the control group . However the formed capsule in Aluminum group was thicker than that in Silver group table(4) fig.(6) . Also the mean numbers of cells in the formed capsules in Aluminum and Silver groups were higher than that in the control group but in Aluminum group it was higher than in Silver group table(3) fig .(5).

Fig.(1-A): Section in the connective tissue capsul surrounding metal free Acrylic resin showing thin capsule Infiltrated with inflammatory cells .
(Hx &E x200)

Fig. (1-B) : High magnification of fig.(1) showing fibroblasts and collagen bundles .
(Hx & E x400)

Fig. (1-C) : Section in the connective tissue Capsule surrounding metal free acryli c resin showing inflammatory cells ; collagen bundles and congested blood vessels.
(Masson trichrome x 200)

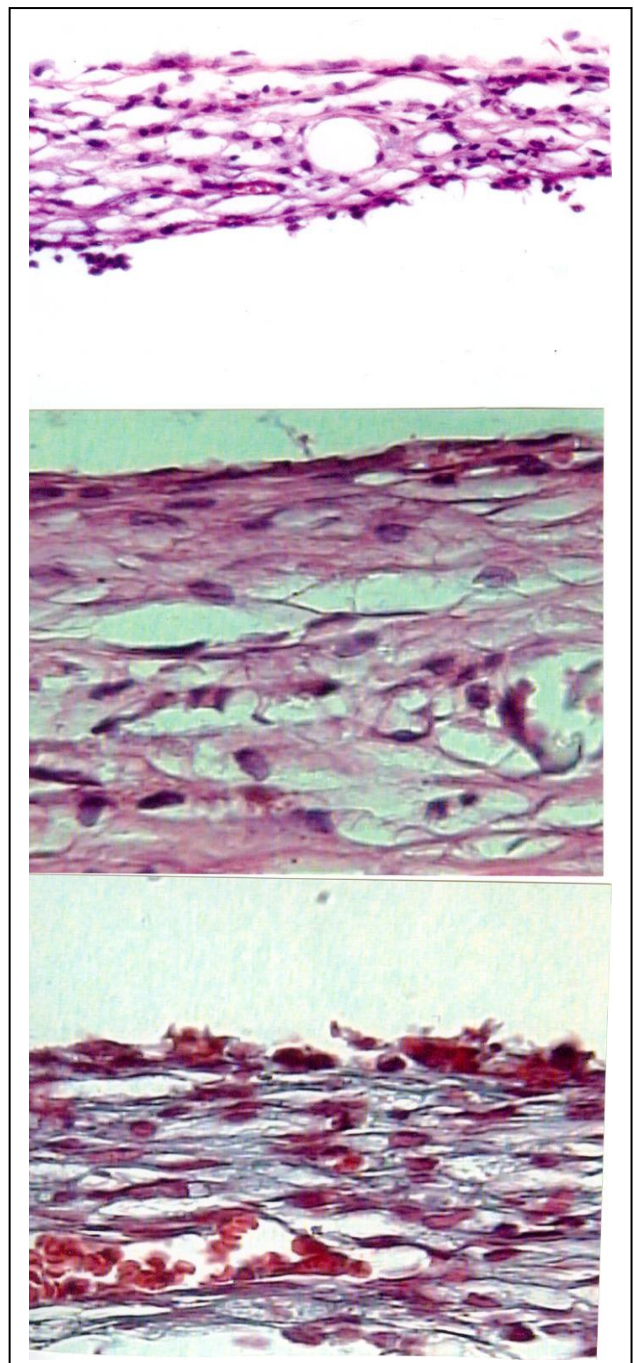


Fig. (2- A) :Section in the connective tissue capsule surrounding Aluminum containing acrylic resin showing thick capsule infiltrated with many inflammatory cells. (Hx &E x 200)

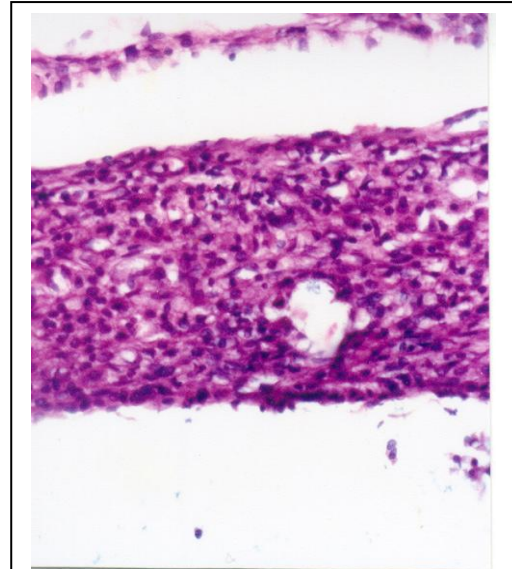


Fig . (2-B) : High magnification of fig. (2-B) showing crowded fibroblasts and dense bundles . (Hx &E x 400)

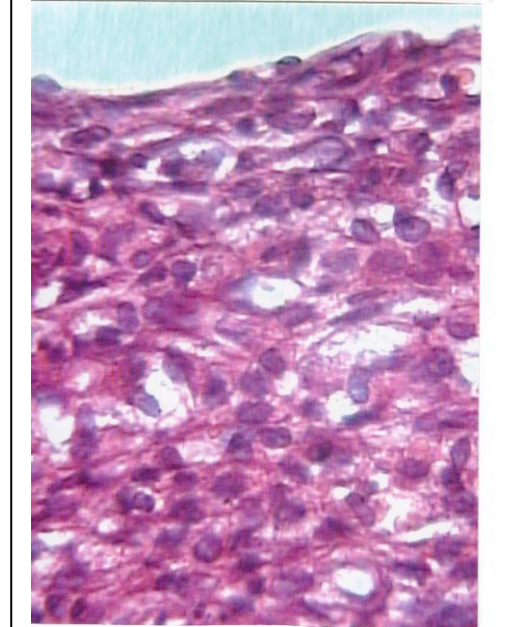


Fig. (2-C) : Section in the connective tissue capsule surrounding Aluminum containg acrylic resin showing crowded inflammatory cells and collagen bundles . (Masson trichrome x 200)

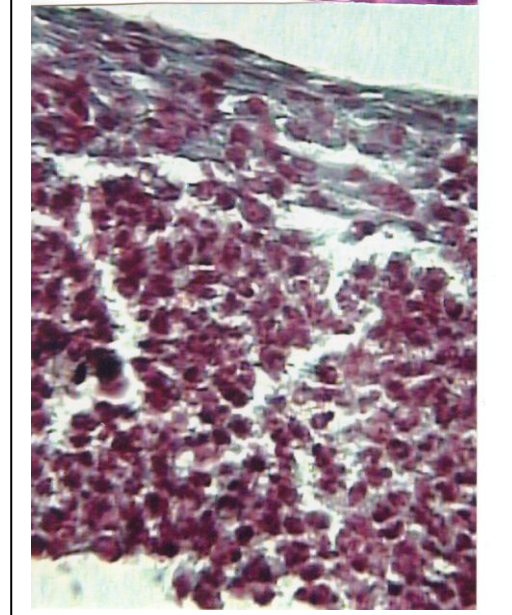


Fig .(3-A) :Section in the connective tissue capsule surrounding Silver containing acrylic resin showing thin capsule infiltrated with inflammatory cells .
(Hx &E x 200)

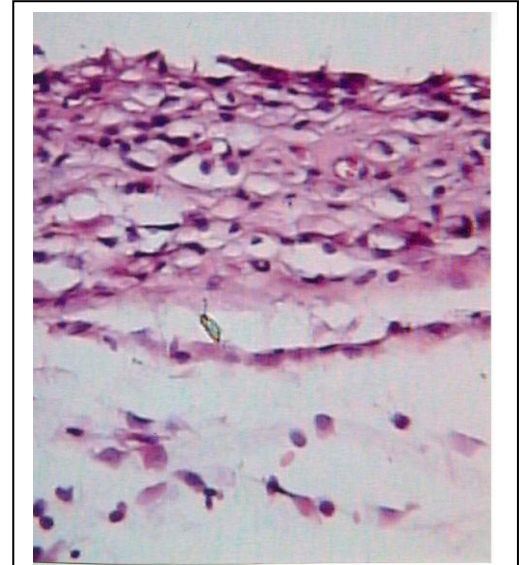


Fig . (3-B): High magnification of fig. (3-A) showing collagen bundles and fibroblasts
(Hx &E x 400)

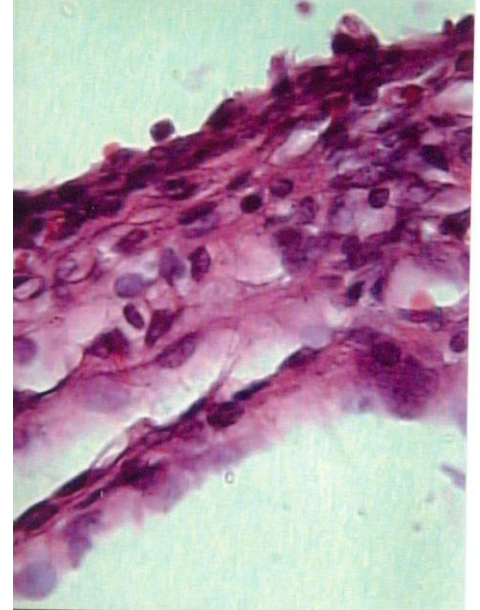


Fig. (3-C) : Section in the connective tissue capsule surrounding Silver containing inflammatory cells and collagen bundles
(Masson trichrome x 200)

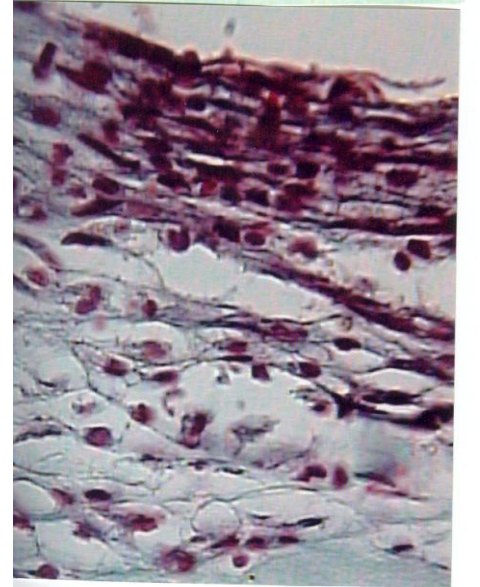


Fig.(4-A): Inflammatory cells in the capsule including numerous fibroblasts (F); a histiocyte(H) ; a neutrophil(N) ;a plasma cell(p) and a lymphocyte(L) Hx&E X400)

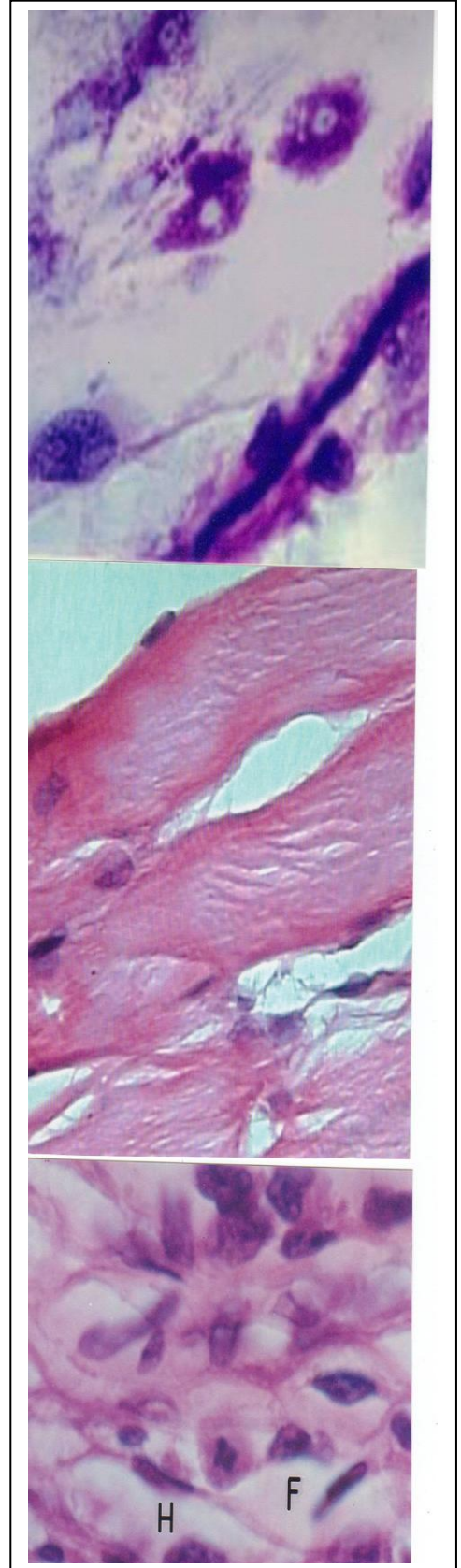


Fig. (4-B) : The formed capsule showing thick collagen bundles and few fibroblasts. (Hx&E x1500)

Fig, (4-C) : The connective tissue capsule showing mast cells ; fibroblasts and lymphocytes (Toluidine blue x1000)

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Table(1): Transverse strength of Silver and Aluminum filled heat cured acrylic resin(Kg/mm²)

MATERIALS	SILVER		ALUMINUM		F . VALUE
	MEAN	S.D	MEAN	S.D	
0 %	8.85	0.71	8.84	0.71	
2 %	8.90	0.11 *	9.02	0.43 *	250.14 *
3 %	8.70	0.12 *	8.50	0.44 *	402.82 *
5 %	7.04	0.76	7.30	0.36	
10 %	5.01	0.86	5.17	0.30	

*= Significant at 5%

Table(2): Transverse strength of Silver and Aluminum filled heat cured acrylic resin(Kg/mm²)

MATERIALS	SILVER		ALUMINUM		F . VALUE
	MEAN	S.D	MEAN	S.D	
0 %	0.48	0.05	0.49	0.04	
2 %	0.60	0.03 *	0.62	0.01 *	46.02*
3 %	0.56	0.03 *	0.50	0.02 *	52.0 *
5 %	0.45	0.04	0.45	0.05	
10 %	0.30	0.06	0.34	0.06	

* = Significant at 5 %

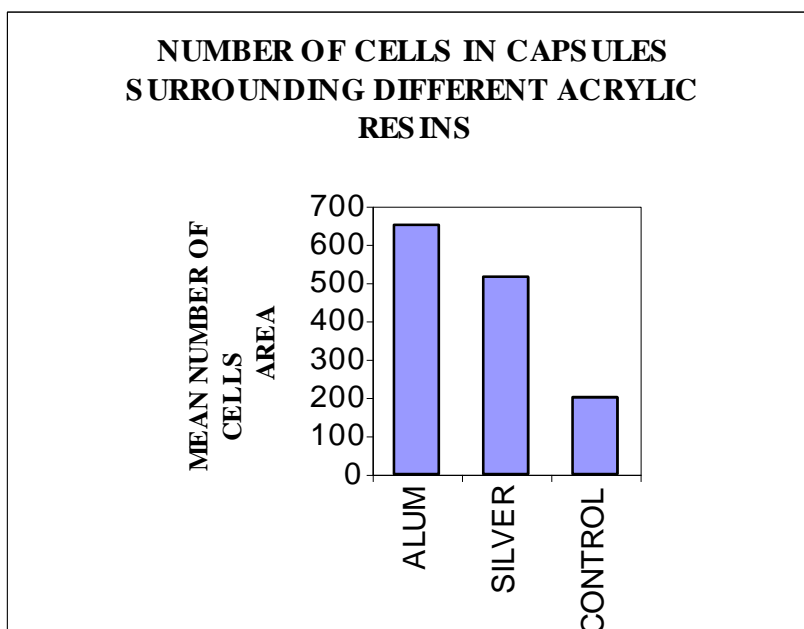


Fig. (5) : Number of cells in the C . T. capsules surrounding different acrylic resins

	ALUM	SILVER	CONTROL
Sum	13000	10300	4000
Mean	650	515	200
Std. Deviation	0.69	0.46	0.24
T value	1.240	1.224	
P value	< 0.05	< 0.05	**

Table (3) : showing quantitative results of the mean number of cells in C.T. capsules of different groups .

** Significant change between metal filler and control groups at P < 0.05

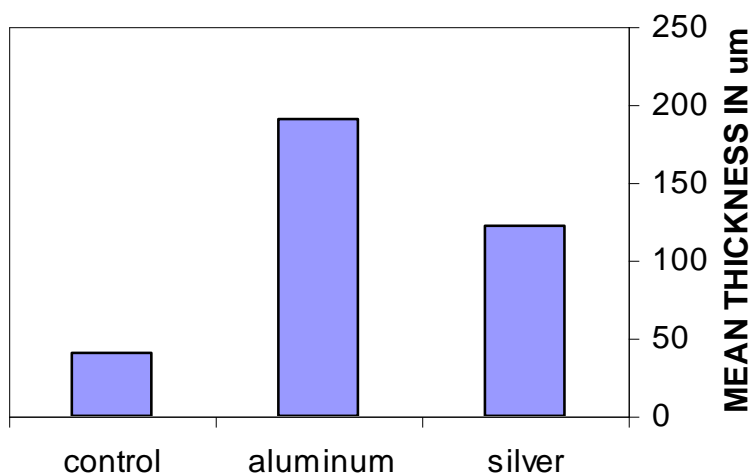


Fig .(6) :Histogram showing the mean thickness of the C . T . capsules surrounding different acrylic resins .

	control	aluminum	silver
Sum	605.61	2858.26	1831.23
Mean	40.374	190.5507	122.082
Std. Error of Mean	0.967495	1.016168	4.280251
Std. Deviation	3.747094	3.9356	16.57734
T value		2.62297	4.63994
P value	***	< 0.05	< 0.05

Table : (4) showing the Quantitative results of measurements of the capsule thickness

***Significant changes between metal fillers and control group at P < 0.05

Discussion

Acrylic resins are widely used materials for denture base processing because they are ease to manipulate . Addition of metals to the acrylic resin was tried by many investigators ; Silver and Aluminum were tried by Schajpal and Sood (1989) and Cupper was tried by Watah et al (2000) . Metals improved the thermal conductivity as well as the mechanical properties of the resin . Similar results was found in this study with 2% concentrations of Al and Ag metals when mixed with the heat acrylic resin . Both the transverse and impact strengths were increased . The subcutaneous C.T. reaction was examined with acrylic resin implants containing 2% Al and Ag concentrations . The tissue reaction against metal free control implants was minimal in the form of thin C.T. capsule formed mainly of collagen fibers and fibroblasts . The mean thickness of the capsule was (40.4±3.7)um. This tissue compatibility was attributed to the high purity and low level of residual monomer in the acrylic resin (Fahim et al ; 1971) . However the tissue reaction with Aluminum was extensively expressed with the thick capsule and the marked cellularity . Histological results showed marked fibroblasts proliferation forming a C.T. capsule with mean thickness(190.6±3.9)um. infiltrated with different inflammmatory cells extravasated from the surrounding congested vessels. The mean cell number was (650±0.69)cell /area. The same results have been reported by Kraft et al.(2000) and wataha et al.(2000). Although Al and Ag showed activation of the surrounding tissue against subcutaneous implants ; reduced cellular proliferation and activity were noticed with silver. The mean cell number was (515±0.46)cell /area and the mean thickness of the capsule was

(122.1±16.6)um . Similar results were reported by Kraft et al(2000) and Wataha et al.(2000).

Aluminium implants releases Aluminum element into the surrounding tissue (Wang et al ;1992) . This free element is phagocytosed by macrop - hages (Elson et al ;1993) . Also ; this low dose of Al was reported to have mitoginic activity (Jeffery et al ;1994) and stimulates DNA synthesis (Quarles *et al*;1 994) Therefor Aluminum stimulates the fibroblast cell activity and division (Zaman et al ; 1992) forming the capsule and inducing the inflammatory reaction with marked cellular activity including macrophages; plasma cells; eosinophils and other leucocytes (Garacia *et al* ; 1995). The persisted tissue reaction after 4 weeks in the form of thick capsule might be related to the intermolecular cross links between the formed collagen fibrills as reported by Zhue et al (1990). However Rowatt *et al* (1979) reported that this tissue reaction was related to the binding action between Aluminum and the phosphorelated serins in tissues . Threfore the binding activity of the added metal to the tissue protein is an important factor in determining the tissue response. In conclusion the addi - tion of low concentrations of Al and Ag to the acrylic resin improved the mechanical properties but the tissue reaction with Ag was better than with Al. Fibroblasts were the prominent cells in the tissue reaction. However these results are encouraging to think in Aluminum as Silver substitute especially for external reconstructive purposes .

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تقييم استجابة النسيج الضام تحت الجلد لعينات مغروسة من اكريل راتنجي مخلوط بحشوات معدنية

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يستعمل الاكريل الراتنجي في عمل التركيبات التعويضية والجراحية في طب الأسنان . وقد أجريت دراسات عديدة بهدف تطوير هذه المادة و في هذه الدراسة تم إضافة كل من برادة الألومنيوم و الفضة علي حدة بنسب 2% ، 3% ، 5% ، 10% إلى الاكريل الحراري المستعمل في التركيبات التعويضية و الجراحية . بعد ذلك تم اختبار الخليط لتحمل القوى العرضية والقوى المباغثة طبقا للاختبارات الدولية المعروفة بتقنية اليسون⁰ و قد أثبتت الدراسة أن إضافة معدني الفضة و الألومنيوم بنسب 2% رفعت من كفاءة الاكريل الحراري في حين قلت كفاءته مع التركيزات العالية الأخرى لذا تم اختيار هذه النسبة للدراسة في عشرين من ذكور الفئران البيضاء البالغة لدراسة التغيرات الهستولوجية في النسيج الضام تحت الجلد المصاحبة لغرس عينات تمثل الاكريل الحراري مخلوطا مع الفضة والألومنيوم كل علي حدة بنسب 2% وعينات أخرى ضابطة خالية من كلا المعدنين . وقد لوحظ ظهور تفاعل بين قرص الاكريل المزروع والنسيج الضام تحت الجلد في صورة كبسولة من ألياف الكولاجين وخلايا الالتهاب في كل الحالات ⁰ غير أن التفاعل الخلوي حول الاكريل الخالي من كل من الفضة والألومنيوم (المجموعة الضابطة) كان بسيطا حيث ظهر ذلك في قياسات سمك الكبسولة المحيطة وكثافة خلايا الالتهاب في حين كان التفاعل زائدا حول عينات الاكريل المحتوي على نسب 2% من مادة الألومنيوم في الأسبوع الثاني ثم قلت حدته في الأسبوع الرابع . أما بالنسبة لعينات الاكريل المحتوي على نسب 2% من مادة الفضة فقد كان التفاعل اقل حدة منه في عينات الألومنيوم وظهر ذلك في قياسات سمك الكبسولة المتكونة وكثافة خلايا الالتهاب كما قلت حدة التفاعل أيضا في الأسبوع الرابع لدرجة كبيرة ولكنها لم تصل إلى نتيجة المجموعة الضابطة . ونستخلص من نتائج هذا البحث انه يفضل إضافة معدني الفضة والألومنيوم إلي مكونات الاكريل الحراري المستعمل في التركيبات التعويضية والجراحية خاصة الخارجية منها مع تفضيل إستعمال الفضة عن الألومنيوم في التركيبات الداخلية.