Evaluation of Tensile Strength and Microhardness of Two Nickel-Chromium Based Casting Alloys with the Addition of Different Ratios Recasted Alloy Using Oxyacetylene Flame Casting Techniques

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الخلاصة

يضطر تقنى الأسنان الى إعادة صب سبيكة المعدن المستعمل في صناعة الطقوم الجزئية المعدنية بسبب ارتفاع كلفة السبيكة مع خلطها بنسب معينه الى المعدن القديم ويعيد صبه.

أجريت هذه الدراسة لقياس قوة الشد والصلابة باستعمال نوعين من السبائك لشركة بيكو وماكس وايتنس.

قسمت العينات الى 3 مجموعات، فى المجموعة الأولى نسبة المعدن المعاد 25% والثانية 50% والثالثة كانت معدن صافى 100% وقد فحصت بأجهزة متخصصة وأظهرت النتائج ان إعادة الصب لسبيكة النيكل كروم مع إضافة 25% و50% لم تؤثر على قوة الشد والصلابة لجميع أنواع السبائك المستعملة ولكن قيمة المعدل لعينات الشد كانت الأعلى للمجموعة الأولى (100%سبيكة جديدة) لكلا النوعين من المعدنين على عكس عينات الصلابة حيث كانت قيمة المعدل للمجموعة الثالثة الأعلى (50%سبيكة جديدة+50%سبيكة معادة) سبيكة بيكو أظهرت اعلي قيم لكل الخواص الميكانيكية المفحوصة مقارنة مع سبيكة ماكس وايتنس.

Abstract:

The objective of this study is to evaluate the tensile strength and micro-hardness of Ni-Cr alloy by adding two different ratios of recasted alloy (25%,50%)and one controlled group (100%fresh alloy),some technicians in our country modifies the casting of Ni-Cr alloy by adding recasted alloy because of high cost of Ni-Cr and low economical state.

We use two different trade mark of Ni-Cr alloy (wiron99 and max-whiteness). According to ANSI/ADA Specification No. 14 (ISO 6871); 30 specimens were made for tensile testing for each alloy type. Another 30 specimens were made for micro-hardness testing which they were square in shape (6mm for each arm and 1mm thickness). ,after statistical analysis it was found that there were no significant differences between each sub-group for the same alloy type for tensile and micro-hardness testing specimens. Although there were a great significant differences between each alloy type.

Introduction:

Turkoz; (1989) [1] evaluated the mechanical properties, such as tensile strength, compressive strength, surface hardness and the elongation and reduction percentages of the length of the metal samples prepared from first, second and third generation castings of a denture base metal. The results revealed only a proportional decrease of surface hardness of the specimens casted from first, second and third melting. While the other properties of all specimens showed no significant differences between themselves. The author concluded that the denture base metals could be melted and recasted again at three times.

Ayad et al., (1996)[2] showed that the use of recasted metal alloys might adversely affect the marginal integrity of gold alloy complete crowns.

Al-Hiyasat and Darmani (2005)[3]studied the effect of recasting on the element release and cytotoxicity of five base metal alloys, two Ni-Cr, Co-Cr and Cu-base alloy. Specimens were casted as following: 100% as received alloy, 50% as-received with 50% recast and 100% recast. Ni-Cr alloy was the least cytotoxic followed by Co-Cr, Ni-Cr-Cu and Cu-base alloy. Reasting of alloys significantly increased their element release and cytotoxic level. The Co-Cr alloy was more adversely affected by the recasting than the Ni-Cr alloy. The Cu content in an alloy increases its cytotoxic level remarkably and its release remarkably increased in proportion with the use of recast alloys, and it was most affected by the recasting process followed by Co and Ni.

Al-Samarrai (2005) [4] showed that the recasting of Co-Cr and Ni-alloys with addition of a as-received alloy in different percentages decrease the Co,Cr, Ni ions release and the recasted Co-Cr alloy showed more corrosion resistance than recasted Ni-Cr alloy..

Material and Method:

Molds and specimens design for tensile and micro-hardness test:

A specimen is fabricated from metal (nickel alloy) according to ADA specification no. 14, for tensile specimens Fig. 1. An impression was made for the pre-fabricated specimen with agar-agar impression material; the agar-agar impression material was softened at 60C°. A duplicating flask was used to duplicate the specimen; a thin layer of dental plaster about 5mm was poured to the bottom of the flask to hold the specimen. The flask filled with the agar-agar impression material till the whole specimen was imbedded in the impression material. The flask placed in a refrigerator for about 3hours, to facilitate setting and hardening of the agar-agar impression material. Once the impression material was set the specimen pulled from the impression and then the impression poured with cold cure acrylic resin. The acrylic specimens were finished with acrylic bur to maintain the original standard dimensions.

The acrylic specimens were flasked in casting ring with phosphate bounded investment, then the moulds put in burn out furnace for about one hour at 900 C° until the acrylic specimens were burned out, finally they held in centrifugal machine so that the molten Ni-Cr (with oxyacetylene flame) were injected into the ring. Since the temperature of the flame was unable to measure; but it was the same for all the three groups; because the valves that allow passage of the gases were controlled, instead we measure the time at which each group were molten; and it was as follow: for group I about 5minutes, group2 8minutes and for group3 it was 10minute s. Figure-1

Figure-1: Tensile specimen

The recasted alloy used once for each group i.e. the sprues from 2nd and 3 rd recasting groups were discarded and not used again.

For micro-hardness specimens a square shape specimen was prepared from acrylic resin its dimensions were 1mm thickness and 6mm for each arm. The standard specimen was duplicated by making impression for the specimen with polysulfide impression material. Finally, the surface of the specimens were highly finished and polished with 500-grit silicone carbide paper under running tap water then finally with pumice to get highly polished mirror like surface. Figure-2

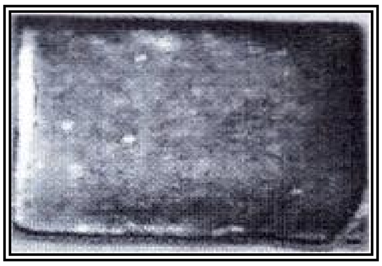

Figure-2: Micro-hardness specimen

Grouping of the specimen:

The ratios of the as-received and recasted alloys for each group type were suggested by a previous study by Muhammad F.Mutlak M.F (2004) [5]

Tensile specimen

As illustrated in figure-3, two types of nickel chromium alloy were used; wiron 99 and max whiteness. Each group consists of 3 subgroups of different mixing ratio of as received and recasted alloy as following:

A- 5 specimens made from as-received nickel chromium 100% group 1.

B- 5 specimens made from as-received nickel chromium for 75% and the remaining 25% were recasted nickel chromium alloy group 2.

C- 5 specimens made from as-received nickel chromium for 50% and the remaining 50% were recasted nickel chromium alloy group 3.

Specimens were tested by Tensile strength tester device that showed in Figure-4.

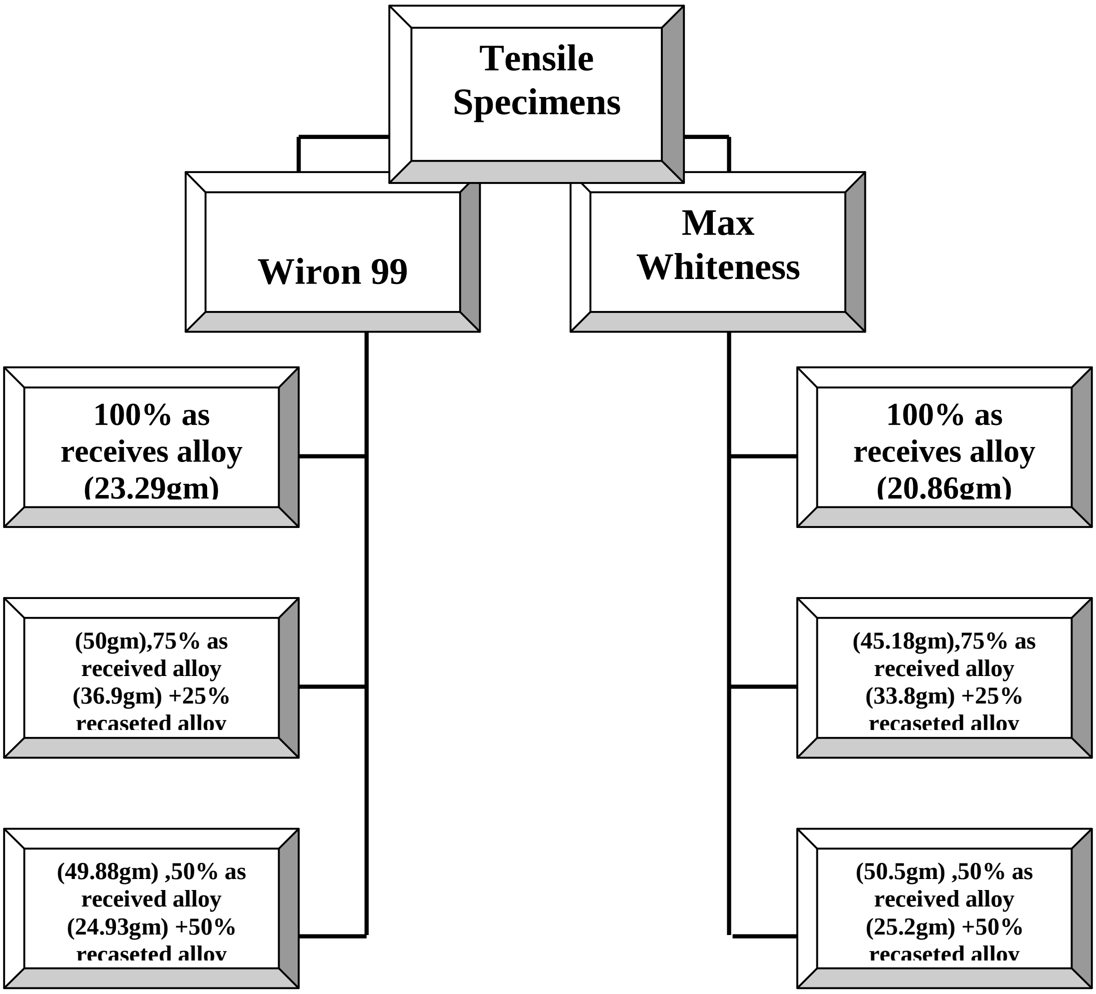

Figure-3: Grouping of the tensile specimens by wt% ratios

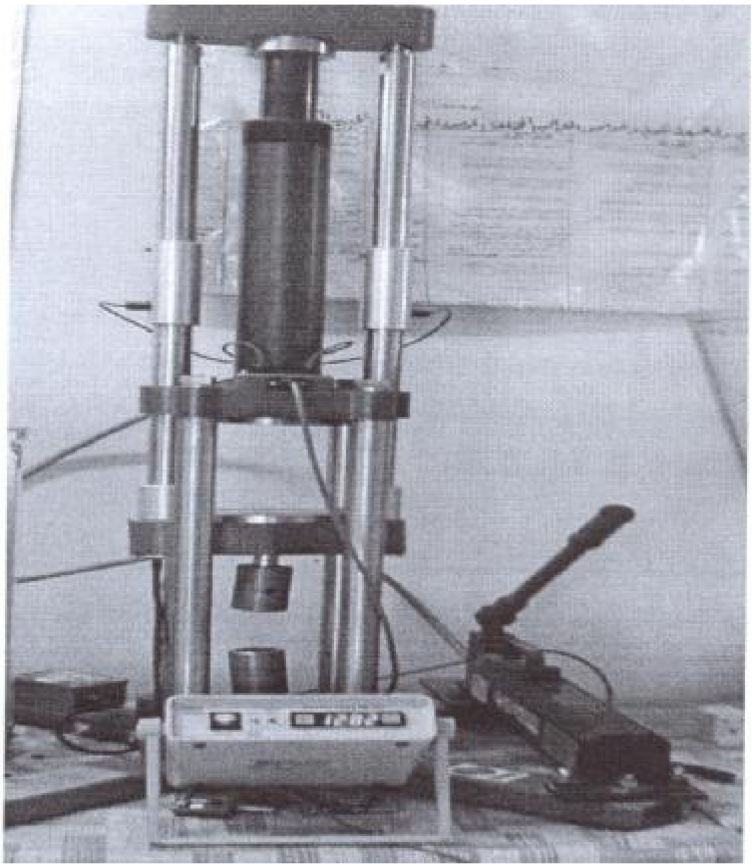

Figure-4: Tensile strength tester

Micro hardness specimens:

As illustrated in figures (5, 2) types nickel chromium alloy groups were used wiron99 and max whiteness. Each group consists of 3 subgroups of different mixing ratios of as received and recasted alloy as following:

A- 3 specimens made from as-received nickel chromium 100% group 1.

B- 3 specimens made from as-received nickel chromium for 75% and the remaining 25% were recasted nickel chromium alloy group 2.

C- 3 specimens made from as-received nickel chromium for 50% and the remaining 50% were recasted nickel chromium alloy group 3.

Specimens were tested by Rockwell hardness tester device that showed in figure-6.

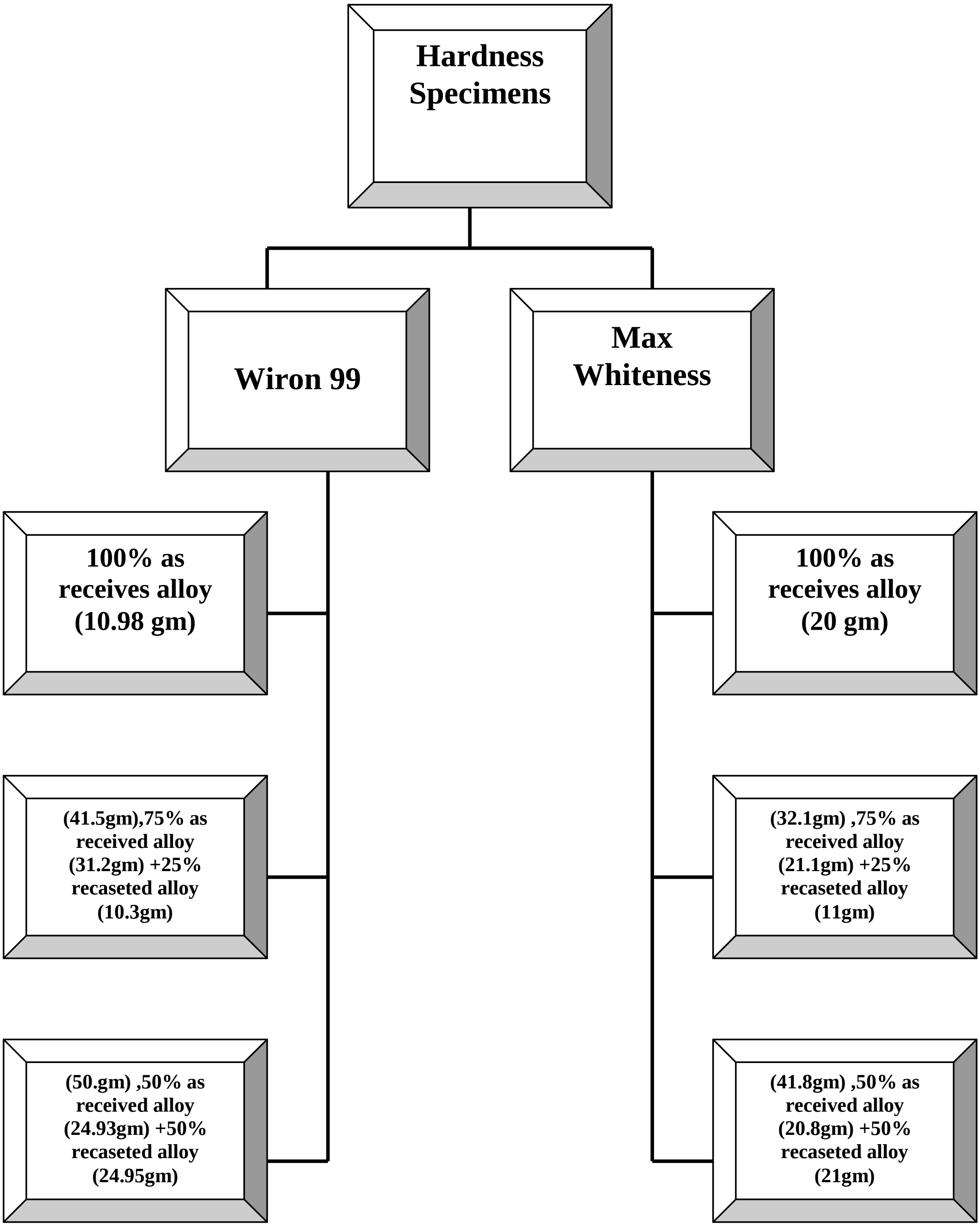

Figure-5: Shows grouping of the hardness specimens by wt% ratios

Figure-6: Rockwell hardness tester

Preparation of the grips for tensile specimens:

An adjustment to the tensile testing machine where needed to hold the tensile specimens, since they are too small to hold by the grips of the machine. Therefore two grips were fabricated from chromium steel burned in a specified furnace to make it very hard (harder than the tested nickel chromium material so as not to affect the readings of the specimen) to adapt the specimen to the tensile testing machine. Each grip was made of two equal halves sliced at the middle to hold the specimen between them securely and a nut size 17 used to close the two grip halves with the specimen between them, and these two grips where held securely by the machine. Figure-7

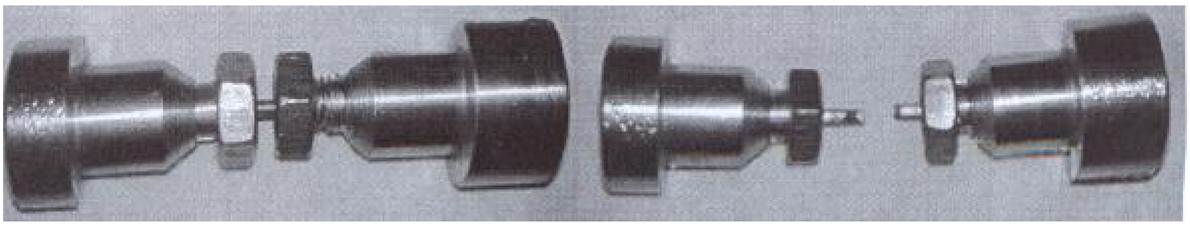

Figure-7: A: The grips holding the tensile specimen before testing.
B: The grips holding the tensile specimen after testing (after rapture).

Results:

Tensile strength:

The Anova test for tensile strength of as-received and recasted groups of both alloy types are illustrated bellow in (Table-1) and (Table-2).

Group 1	0.000	1.101	1.00	N.S
Group 2	4.000	1.101	0.01	S.
Group 2	0.000	1.101	1.00	N.S
Group 1	4.000	1.101	0.01	S.
Group 3	-4.000	1.101	0.01	S.
Group 1	-4.000	1.101	0.01	S.

Table-1: Anova test of the tensile strength of the max whiteness samples

Group 3	Group 1	-7.000	2.046	0.015	S
	Group2	-3.800	2.046	0.264	N.S
Group 1	Group3	7.000	2.046	0.015	S
	Group2	3.200	2.046	0.431	N.S
Group 2	Group3	3.800	2.046	0.264	N.S
	Group1	-3.200	2.046	0.431	N.S

Table-2: Anova test of tensile strength for wiron99

Micro-hardness:

The Anova test for micro hardness of as – received & recasted groups of both alloy types are illustrated as follows in table-3 and table-4:

		Mean difference	Std. Error	Sig.	
G.1	**G.2**	-1.33	1.305	1	N.S
	G.3	-3.66	1.305	0.092	N.S
G.2	**G.1**	1.33	1.305	1	N.S
	G.3	-2.33	1.305	0.372	N.S
G.3	**G.1**	3.66	1.305	0.095	N.S
	G.2	2.33	1.305	0.372	N.S

Table-3: Anova test for mean of RHN of max whiteness

		Mean difference	Std. Error	Sig.	
G.1	**G.2**	-0.66	1.67	1	N.S
	G.3	-5.33	1.67	0.092	N.S
G.2	**G.1**	0.66	1.67	1	N.S
	G.3	-4.66	1.67	0.372	N.S
G.3	**G.1**	5.33	1.67	0.095	N.S
	G.2	4.66	1.67	0.372	N.S

Table-4: Anova test for mean of RHN of wiron99

Discussion:

The effect of recasting:

Tensile strength:

For max whiteness metal alloy showed a non-significant difference in the tensile strength between the as-received Ni-Cr metal alloy and (75% as-received Ni-Cr metal alloy +25% recasted Ni-Cr metal alloy), while a significant difference existed when comparisons were made between (50% as-received Ni-Cr metal alloy and 50% recasted Ni-Cr metal alloy) and the other groups separately the same result was observed for wiron99 metal alloy.

While researches made by Strandman (1976) [6], Sheffick (1993) [7] and Abdul-Munim (1994) [8] showed that carbon content of the metal alloy change markedly with repeated melting. The possible explanation is the accumulative gain of carbon from the casting crucible itself with repeated melting. It is observable in laboratories that repeated use of the crucible would render it thinner. This agrees with Craig and Powers (2002) [9] reported that almost all elements in Ni-Cr metal alloys such as chromium, molybdenum and silicon reacts with carbon to form carbides, thereby changes the properties of the metal alloy. If the carbon content where increased by 0.2% over the desired amount, the metal alloy becomes too hard and brittle and could not be useful for making any of the dental appliances. Conversely, a reduction of 0.2% in the carbon content would reduce the metal alloy's yield and ultimate tensile strengths to such low values that, once again, the metal alloy would not be usable in dentistry.

There were high significant differences between the two metal alloy types (wiron99 and max whiteness). Bridgeport et al. (1993) [10] and Craig and Powers (2002) [9] reported that the possible explanation for this could be due to the difference in the composition of minor metal alloying elements that may more or less affect the strength of the casted metal alloy.

Micro-hardness:

Non-significant differences were observed between the different groups of both alloy types but the alloys in the as-received condition showed lower hardness values than those of the respective alloys after casting.
Concerning the casting conditions, the hardness values were higher when the casting procedures performed in a non-controlled atmosphere (flame/air) i.e. blowtorch, because Ni-Cr alloys are more susceptible to contamination by carbon and gas uptake from the atmosphere (like oxygen, hydrogen and nitrogen) than from heat source elements itself.

Leinfelder (1989) [11] found that the oxidation of an alloy elements make it harder. In principle, adhesive oxide formers (typically indium, gallium and tin in precious metal alloys as well as elements such as tantalum and chromium , cobalt , nickel , uronmetc …) were subjected to increased oxidate . This could be due to the low atanic radiusolthe carbon atom , which allows its diffusion into the lattice , and the format of an interstit..

Phillips (1991) [12] found that the higher hardness values reached by the metal alloys when casted with the blowtorch (flame/air) were because of the ability of some metal alloying elements (such as chromium, titanium, niobium, silicon, molybdenum) in forming carbides. Covington et al: (1985) [13] stated that the amount of carbon absorbed by the metal alloy could be even higher when the metal alloy is overheated. Baran (1979) [14] reported that the uptake of carbon modifies the metal alloy microstructure and its mechanical properties.

However a high significant difference found between the corresponding groups of both metal alloy types, the explanation for this could be due to the difference in the composition of minor metal alloying elements that may more or less affect the strength of the casted metal alloy. This agrees with Bridgeport et al. (1993)[10] and Craig and Powers (2002) [9].

Finally, it could be summarize that recasted Ni-Cr metal alloy showed good results concerning measured microhardness property that could be used instead of as-received alloy that is more expensive for fabrication of fixed prosthesis , while recasting in guued decrease the tenste strength of Ni-Cr-alloy in different degrees for different ratios of recasting alloy so it is preferable not to use the recasted alloys for fabrication of dental prosthesis that require flexibility like clasps and metal frame works connectors .

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