Original Article

Dentistry Section

Dental Prosthesis: An Evaluation on Mechanical Properties of Recast Base Metal Alloys

PRABHU R., GEETHA PRABHU K.R., T. ILANGO

ABSTRACT

Introduction: Dental casting alloys have found widespread usage in restorative dentistry owing to their physical, biological and economical properties. Recent technologies have been applied to these alloys to improve their utility, longevity and efficiency.

Purpose of the Study: The current study aimed at evaluation of recast base metal nickel-chromium alloy with or without addition of new alloy based on their mechanical properties.

Materials and Methods: The study evaluated 10 samples each of fresh alloy, recast alloy with addition of 50% of wt. of new alloy and recast alloy without addition of new alloy. Samples were subjected to computerized Universal Testing Machine and mechanical properties viz. tensile strength, yield strength, percentage of elongation, modulus of elasticity and micro-hardness was tabulated. Data was subjected to multiple post-hoc test of significance.

Results: Significant changes were observed in recast alloy with and without addition of new alloy in contrast to fresh alloy.

Conclusion: Recast alloys used in fixed dental prostheses without addition of new alloy show degenerative changes when compared to unused alloys after casting.

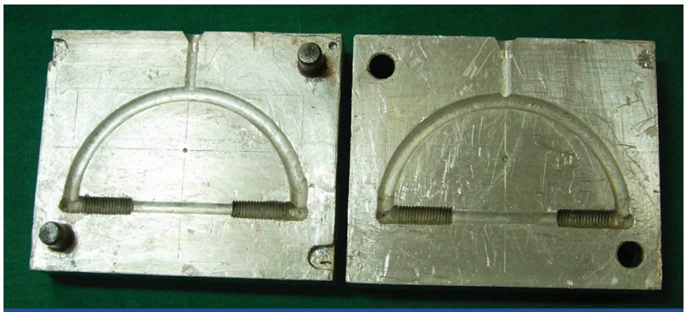
Key Words: Base Metal Alloys, Casting, Recasting, Fixed Partial Dentures

INTRODUCTION

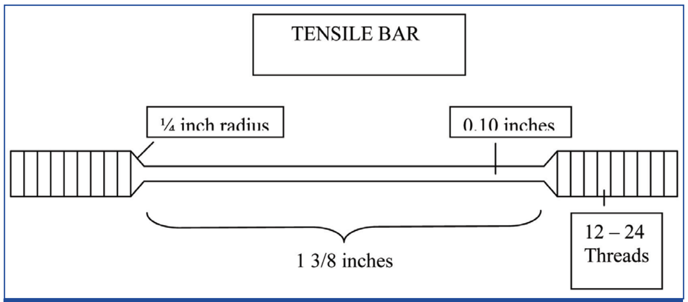
Dental Alloys have been considered to be of paramount importance in the field of fixed partial denture prosthodontics [1]. Mechanical properties, bio-compatibility, working characteristics, casting accuracy, corrosion resistance, porcelain-to-metal compatibility and unit costs are some of the considerations in the selection of an alloy for metal ceramic restorations [2-4]. Although there have been several reports available on the repeated usage of precious metals and the evaluation of their mechanical properties, before and after recast procedures there are few reports available on the evaluation of the mechanical properties of the non-precious base metal alloys after recasting [5,6]. The properties such as micro-hardness, tensile strength, yield strength, modulus of elasticity and percentage of elongation need evaluation after recast as they are directly linked to long term performance [7]. This study was under taken with the aim to evaluate the mechanical properties such as tensile strength, yield strength, percentage of elongation, modulus of elasticity and micro-hardness of recast base metal nickel chromium alloy after casting without addition of any new parent alloy and with addition of 50% new alloy by weight as recommended for recasting of precious alloy castings.

METHODOLOGY

An Aluminum die was fabricated to prepare specimens used for this study according to specifications recommended by the American Dental Association [Table/Fig-1]. The specimens were prepared in auto-polymerising acrylic resin to avoid distortion. The cylindrical acrylic of each specimens had a length of 13/8 inches with a uniform diameter of 3mm. Both the ends of the specimen was made as a threaded cylindrical portion consisting of 12-24 threads with a 1/4 inch radius of curvature [Table/Fig-2]. The sprue portion is designed in order to supply the sufficient amount of metal necessary for recasting procedure. Ingots of nickel – chromium alloy (Heraenium S) were used for casting in this study and was done in three stages. The first stage consists of preparing the base metal alloy specimens made from 100% new alloy to be used as the control group [Table/Fig-3]. The second stage consists of preparing the recast base metal alloy specimens without addition of any new alloy [Table/Fig-4]. The third stage consists of preparing the recast base metal alloy specimens with addition of new alloy by weight [Table/Fig-5]. Total of 10 specimens were made in each stage. Tensile strength, yield strength, percentage of elongation and modulus of elasticity measurements were determined for each specimen according to ADA specification by using fully computerized universal testing machine (Lloyd's universal testing machine). Each specimen was subjected to tensile test with a head speed of 0.1 cm / min and a 500 kg load cell. The computerized graph recorder was set at 5 cm/min. After rupture of each test bar, ultimate tensile strength was computed by dividing maximum recorded load by the diameter of the tensile bar. Offsets of 0.2% were used as arbitrary values to calculate the yield strength. This was accomplished by plotting lines to represent each offset parallel to the straight line portion of the tensile curve which was done by the computer programmed to the testing machine. Fully digitized universal testing machine automatically calculated the values of percentage of elongation after the rupture of each tensile specimen [Table/Fig-6]. Calculating the ratio of stress to strain for each specimen from the slope of the straight line portion of the tensile curve yielded the modulus of elasticity. One end of each fractured tensile specimen was evaluated using Digitized Vickers micro hardness tester using 136° diamond for micro hardness [Table/Fig-7].



[Table/Fig-1]: Aluminum Die

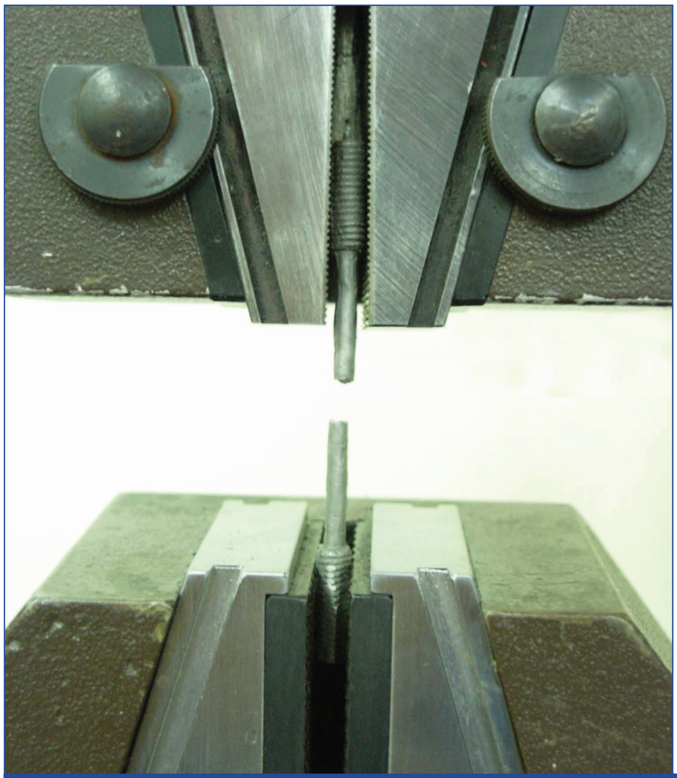


[Table/Fig-2]: Line Diagram representing samples

[Table/Fig-3]: Sample Group I: Fresh alloy

[Table/Fig-4]: Sample Group II: Recast Alloy with addition of new alloy

[Table/Fig-5]: Sample Group III: Recast Alloy without addition of new alloy



[Table/Fig-6]: Universal Testing Machine

[Table/Fig-7]: Digitized Vickers micro hardness tester

RESULTS

The values tabulated for the properties of tensile strength, yield strength, percentage of elongation, modulus of elasticity and micro-hardness for the fresh alloy after casting, recast alloy without addition of any new alloy and with addition of new alloy was given in [Table/Fig-8a, 8b, and 8c] respectively.

[Table/Fig-8a, 8b, 8c, 8d and 8e] shows the mean difference and p-value amongst the three groups viz. fresh alloy, recast alloy with addition of new alloy and recast alloy without addition of new alloy; for the properties of tensile strength, yield strength, percentage of elongation, modulus of elasticity and microhardness, respectively. The values were computed using multiple comparison Post-hoc statistical test. p-value below 0.05 was considered to be significant.

Mean difference for tensile strength compared between fresh alloy and recast alloy with addition (p=0.000) and without addition (p=0.001) of new alloy was found to be significant. [Table/Fig-9a] Test of significance for mean difference values for modulus of elasticity compared between fresh alloy and recast alloy without addition (p=0.038) of new alloy was found to be statistically

Data Tabulated

Speci-mens	Tensile strength (Kg/Cm²)	Yield Strength (0.2% offset) (Kg/Cm²)	Percent-age of Elongation (%)	Modulus of Elasticity × 10^6 (Kg/Cm²)	Micro-hardness (VHN)
1	7360.30	5574.48	32	29	430
2	7091.40	4904.90	24	24	410
3	6974.52	4873.11	20	24	380
4	6541.17	4714.12	27	16	395
5	6816.43	4894.37	28	17	400
6	7219.24	5018.10	30	20	450
7	6705.12	4782.40	21	21	450
8	6650.41	4497.71	32	32	410
9	6414.10	4312.10	30	30	440
10	7065.12	5101.43	29	19	450

[Table/Fig-8a]: Nickel Chromium Base Metal Alloy Castings – Fresh Alloy (Control Group)

Speci-mens	Tensile strength (Kg/Cm²)	Yield Strength (0.2% offset) (Kg/Cm²)	Percent-age of Elongation (%)	Modulus of Elasticity × 10^6 (Kg/Cm²)	Micro-hardness (VHN)
1	5069.01	4516	25	15.90	320
2	6214.12	4619	20	20.12	300
3	6105	4589	29	19.20	339
4	6346	4410	28	18.75	368
5	6835	4849	21	20.21	372
6	5742	4678	27	18.40	334
7	5512	4358	27	17.10	386
8	5814	4369	26	16.08	352
9	6210	5012	22	22.96	366
10	5046	4417	16	16.12	348

[Table/Fig-8b]: Nickel Chromium Base Metal Alloy Castings – Recast (Without Addition of New Alloy)

Speci-mens	Tensile strength (Kg/Cm²)	Yield Strength (0.2% offset) (Kg/Cm²)	Percent-age of Elongation (%)	Modulus of Elasticity × 10^6 (Kg/Cm²)	Micro-hardness (VHN)
1	6282	4788	21	21.19	350
2	6163	4669	29	18.59	363
3	5968	4452	18	17.98	369
4	5895	4348	21	22.01	343
5	6323	5043	24	23.86	386
6	6415	5155	20	19.89	348
7	6188	4963	21	20.68	353
8	6558	5082	27	28.16	378
9	5543	4576	23	22.92	383
10	6055	4832	25	26.12	400

[Table/Fig-8b]: Nickel Chromium Base Metal Alloy Castings –Recast (With Addition of New Alloy)

significant. [Table/Fig-9d] Similarly the mean difference for microhardness of fresh alloy and recast alloy with addition (p=0.000) and without addition (p=0.000) of new alloy was found to be significant. [Table/Fig-9e]) All other mean difference values between the three test groups evaluated for various mentioned properties were not significant.

Statistical Analysis (Multiple Comparison-Post Hoc Test)

Base metal alloy casting	Mean Difference	p value
Fresh alloy (Control group) vs Recast (without addition of new alloy)	994.47	0.000*
Fresh alloy (Control group) vs Recast (with addition of new alloy)	744.78	0.001*
Recast (without addition of new alloy) vs Recast (with addition of new alloy)	–249.69	0.552

[Table/Fig-9a]: Nickel Chromium Base Metal Alloy Castings for Tensile Strength

*The mean difference is significant at the 0.05 level.

Base metal alloy casting	Mean Difference	p value
Fresh alloy (Control group) vs Recast (without addition of new alloy)	285.57	0.097
Fresh alloy (Control group) vs Recast (with addition of new alloy)	76.47	1.000
Recast (without addition of new alloy) vs Recast (with addition of new alloy)	–209.10	0.330

[Table/Fig-9b]: Nickel Chromium Base Metal Alloy Castings for Yield Strength

Base metal alloy casting	Mean Difference	p value
Fresh alloy (Control group) Vs Recast (without addition of new alloy)	4.40	0.059
Fresh alloy (Control group) Vs Recast (with addition of new alloy)	3.20	0.248
Recast (without addition of new alloy) Vs Recast (with addition of new alloy)	–1.20	1.000

[Table/Fig-9c]: Nickel Chromium Base Metal Alloy Castings for Percentage of Elongation

Base metal alloy casting	Mean Difference	p value
Fresh alloy (Control group) vs Recast (without addition of new alloy)	4.72	0.038*
Fresh alloy (Control group) vs Recast (with addition of new alloy)	1.06	1.000
Recast (without addition of new alloy) vs Recast (with addition of new alloy)	–3.66	0.145

[Table/Fig-9d]: Nickel Chromium Base Metal Alloy Castings for Modulus of elasticity

* The mean difference is significant at the .05 level.

Base metal alloy casting	Mean Difference	p value
Fresh alloy (Control group) vs Recast (without addition of new alloy)	54.20	0.000*
Fresh alloy (Control group) vs Recast (with addition of new alloy)	53.00	0.000*
Recast (without addition of new alloy) vs Recast (with addition of new alloy)	–1.20	1.000

[Table/Fig-9e]: Nickel Chromium Base Metal Alloy Castings for Micro hardness (VHN)

*The mean difference is significant at the .05 level.

DISCUSSION

With an exponential demand for base metal alloys in restorative dentistry and a proportional increase in their cost, continual attempts have been made to utilize these metals more efficiently and conservatively. Recasting is a technique carried out to reuse cast nickel chromium alloys in the motive to conserve alloy wastage [8,9].

Firing of porcelain on the metal sub-structure of a restoration at high temperatures may produce changes in mechanical properties that could influence the behaviour of an alloy and its clinical performance during long term usage [10-12]. Harcourt remolded cobalt chromium alloy and found out that after six successive remeltings average value of ultimate tensile strength and yield strength was reduced [13]. Hesby et al studied physical properties of a repeatedly used non-precious metal alloy [14]. Hardness, tensile strength and behaviour percentage of elongation of cobalt chromium alloy were compared between single melt alloy castings and second, third and fourth generation melt alloy castings. Statistical comparisons of the first through fourth generations showed no significant differences. Presswood RG investigated the castability of multiple recast of a nickel chromium beryllium alloy and found that the alloy was sufficiently stable to consummate multiple castings, assuming that the ultimate composition should be considered the same as that of the original alloy [15]. Khamis E, Seddik M et al investigated the corrosion resistance of recast non-precious Ni-Cr and Co-Cr commercial dental alloys in saliva and saline media. The alloys containing cobalt and molybdenum showed higher corrosion resistance than those containing nickel [16]. Additionally, their corrosion resistance was not affected by successive melting and recasting [17].

Based on the results of the conducted study, recast alloys without addition of any new alloy shows greater value of degenerative change for the evaluated properties of tensile strength, yield strength, percentage of elongation, and modulus of elasticity micro-hardness when compared to the fresh alloy after casting. The values obtained for the recast alloy with addition of 50% alloy by weight were in between the values obtained for the fresh alloy after casting and the recast alloy without addition of any new alloy which indicates consideration of recast alloy with addition of minimum of 50% of new alloy by weight for casting procedures. Other properties like bio-compatibility, working characteristics, casting accuracy, corrosion resistance and porcelain–to–metal compatibility should also be examined for long term clinical usage when recast alloys with addition of new alloy were considered.

CONCLUSION

Recast nickel chromium base metal alloys without addition of new alloy show degenerative changes when compared to fresh unused alloys after casting. Recast nickel chromium base metal alloys with 50% addition of new alloy by weight can be considered during the casting of alloys for fixed partial denture on the basis of limited mechanical properties evaluated during this study.

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AUTHOR(S):
1. Dr. Prabhu R.
2. Dr. Geetha Prabhu K. R.
3. Dr. T. Ilango

PARTICULARS OF CONTRIBUTORS
1. Corresponding Author
2. MDS, Reader,
Department of Prosthodontics,
Thai Moogambigai Dental College and Hospital,
Mogappair, Chennai - 600 107
Tamilnadu, India.
3. MDS, Professor
Department of Prosthodontics,
Thai Moogambigai Dental College and Hospital,
Mogappair, Chennai - 600 107
Tamilnadu, India

NAME, ADDRESS, TELEPHONE, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. R. Prabhu, MDS
Reader, Dept. of Prosthodontics,
Thai Moogambigai Dental College and Hospital,
Mogappair, Chennai-600 107
Phone. 09840891669
E-mail: drprabhu77@gmail.com

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