

## Characterization and Crystallographic Evaluation of Wrought Stainless Steel Used As Wrought Framework in Acrylic Partial Denture - An In Vitro Study

K .Ramkumar<sup>1</sup>, G.Gomathi<sup>1</sup>

1.Department of Dental Surgery , Stanley Medical College & Hospital ,Chennai

Corresponding Author: K .Ramkumar

**Abstract:** One of the treatment option for Partially edentulous condition is by removable partial denture . The treatment option of partially edentulous condition is casts partial denture (CPD) & acrylic partial denture which is known as transient partial denture (TPD) widely. The designing concept of CPD is justified biologically & mechanically when compared to TPD. In our country TPD is widely used as definitive prosthesis because it is economical when compared to the CPD . Hybrid partial denture where in which wrought bars made of stainless steel were used to connect the right and left half of the arch , as a result the acrylic coverage is reduced well .A case series of partial denture rehabilitated with wrought frame is presented here . An observational study was conducted with the aim of analyzing the metallurgy of stainless steel. The component present in the wrought frame work was analyzed using plasma emission spectroscopy . The main alloying element being Chromium 13 % .Wrought frame work when subjected to cold working the crystal structure will be altered resulting in catastrophic failure of the metal. Annealing was done to relive the stress and to get the lattice in arranged manner. The changes in the frame work before and after annealing was analyzed using optical microscope .The result of annealing is well appreciated by the ordered arrangement of the crystals.

**Key words:** Transient partial denture (TPD) , Wrought alloy , Annealing ,Stainless steel

Date of Submission: 13-02-2019

Date of acceptance: 28-02-2019

### I. Introduction

The treatment option of partially edentulous condition is rehabilitated by cast partial denture (CPD) & acrylic partial denture which is known as transient partial denture (TPD) widely .The most important criteria in the designing of removable partial denture (RPD) is to distribute the stress to the underlying bone and & periodontal ligament , this distribution of stress is possible only in CPD. The designing concept of CPD is justified biologically & mechanically when compared to TPD. Acrylic partial denture is widely considered as treatment option in the various part of the world. The ratio of cast partial denture to the acrylic partial denture is 1:5 according to the Dental Practice Board website of NHS<sup>1</sup>. A survey In Singapore reports acrylic partial denture is more preferred treatment option for partially edentulous condition<sup>2</sup>. The advantages of acrylic partial denture are cheap, easy to construct, and easy to modify are the reason for wide acceptance both by the clinicians and the patient. The disadvantages of acrylic partial denture are weak material ,non rigid ,must be bulk for strength ,and high potential for soft tissue damage<sup>2</sup>. Every type acrylic partial denture is modification of the acrylic partial denture with some modification such as reducing the coverage , retention by following the principles of complete denture ,distal stabilizers .The advantages of CPD and TPD are combined and hybrid partial denture are made and the details are discussed in the case report .The metallurgy of the palatal bar and the method of annealing to relive the stress are discussed in detail .

### II. Case Report(A)

A female patient age 41 reported to Tamil Nadu Govt Dental College &Hospital ,Chennai India complaints of difficulty in chewing, on examination she had missing teeth 45,46,34,35,36,37,11,16 .Transient removable partial denture with wrought bar frame work was planned, bar was procured from Hema dental , Chennai ,India . In the denture base minor connector area wrought mesh frame work was planned and it was brought from Vijay Dental Chennai, India. The bar was bend to the required contour and adapted to the cast. Wrought mesh was cut to the required contour and adapted to the denture base area (fig 1).Frame work and the mesh were stabilized using plaster of paris , and both of them were joined together using silver solder (fig 2) .Bite block was fabricated and bite registration recorded , wax try in done 21 gauge wire was used to provide the retention and the processing was done using heat cure denture base resin. The partial denture was delivered

occlusion and the fit of the prosthesis were evaluated patient was comfortable with limited coverage of the frame work (Fig 3).

### **III. Case Report(B)**

A female patient age 38 reported to TNGDC &H ,Chennai ,India with complaints of difficulty in chewing , on examination she had missing teeth 15,16,25,26.The periodontal status of the abutment were not favorable for fixed partial denture hence removable partial denture with wrought frame was planned .The steps followed in the above case was followed and the partial denture was delivered (Fig 4,5,6) .

Metallurgy of the stainless steel (palatal bar):

Wrought frame work used in removable partial denture is mainly stainless steel .Stainless steel basic component is iron ,remaining component consist of 12% to 30 % of chromium ,traces of nickel and carbon , based on the crystal structure of iron present in stainless steel it is classified into Ferritic (bcc), Austenitic ( fcc) ,Martensitic (bct).Ferritic stainless steel has little application in dentistry widely used in industry .Martensitic stainless steel are used for surgical and cutting instruments .Austenitic stainless steel are widely used in dentistry it comes under AISI 300 series. Type 302 consist of basic component iron and the remaining is 17 to 19 % of chromium ,8to 10% nickel and maximum of 0.15% of carbon.Type 304 consist of 18 to 20 % chromium and 8%to 12%nickle ,along with maximum carbon content of 0.08%.Both 302 & 304 are often given general designation of 18-8 stainless steel.Type 316 L (low carbon) contains 10 to 14 % nickel ,2%to3%molybdenum,16%to 18% chromium and 0.03%maximum carbon used in implant dentistry.

Characterization of stainless steel

Analysis of the elements can be done by atomic absorption spectroscopy (AAS) and by atomic emission spectroscopy (AEES). The component present in the bar used to rehabilitate the partial edentulous situation is assessed by plasma emission spectroscopy. A plasma may be defined as a cloud of highly ionized gas ,composed of electrons,ions and neutral particles. Plasmas can conduct electricity and are affected by magnetic fields .These are composed of highly energetic and ionized gases and are produced in inert gases like argon etc. They are useful not only for dissociation of atoms but also for excitation and ionization to give atomic and ionic emission.

The instrument has a coaxial tube ,argon is passed in to the tube and radiofrequency signal is applied as a result argon gets charged and produces electrons and charged ions .A spark is applied at the mouth of the coaxial tube to produce plasma , this plasma is made to hit the sample it under go various transformations like desolvation, vapourisation ,atomization ,ionization, and excitation during this process atoms get excited from higher energy to lower energy state it release light rays which of polychromatic. Separation is done by monochromator and detection by a photomultiplier tube( Fig 7) . The composition of the palatal bar used for making the frame work is shown in table 1.

The palatal bar used for this case are bent with heavy duty pliers to greater extent which will result in development of internal stress which are not desirable since they may cause premature ,sudden brittle failure of the structure and the frame shape will not be maintained and deformed on long use . Annealing will be a solution to relieve the stress developed .Preheat furnace supplied Dentsply which can control the raise of temperature per degree and can hold the temperature is used to do the annealing heat treatment The temperature is raised to 6.25 degree per minute up to 375 degree Celsius and hold for 4 minutes and cooled to room temperature in the furnace .

The change in the microstructure of the palatal bar were assessed under an optical microscope. Palatal bar before annealing and after annealing were sectioned and invested in Bakelite and it was sectioned until the samples were visible the surface of the samples were treated and the visualized under optical microscope . fig (8 ) shows the optical microscopic view of the palatal bar before annealing and the fig(9 ) shows the optical microscopic view of the palatal bar after annealing. On comparing the two figures the grain size after annealing are coarse the effect of heat treatment is appreciated .

Discussion:

Partially edentulous condition can be restored by cast partial denture, acrylic partial denture .Rehabilitation of partially edentulous by cast partial denture is the treatment of choice because it has sound biological and mechanical principles. Inclusion of major connector, minor connector, rest in the design of cast partial denture, distribute the stress to the tooth and the edentulous ridge. Acrylic partial denture is non rigid ,weak material ,must be bulky for strength and high potential to damage the soft tissue in spite of all this disadvantages it is widely used by the clinicians .The figures obtained from the Dental practice board web site shows that for every denture that involves a cobalt –chrome frame work ,there are five dentures that are made from acrylic. The concept of cast partial denture and acrylic partial denture are combined and wrought frame was used to rehabilitate the partially edentulous situation in this cases have been tried. The concept of wrought frame work in restoring the partial edentulous condition limits the coverage and improves the taste sensation.

Wrought base metal are used for orthodontic wires ,root canal files and reamers ,crowns in pediatric dentistry , and surgical instruments .The major application of wrought wire is in the field of orthodontics, stainless steel ,beta titanium , nickel titanium, are the materials widely used .In removable partial denture wrought wires are limited to fabrication of clasp for removable partial dentures .Rudolf scheu in his book “ wrought wire technique for partial dentures “ 1958 discuss about the various application of wrought alloys in removable partial denture . He used wrought wire to fabricate C-clasp, G-clasp, E- clasp, J –clasp and various other designs to provide retention in removable partial dentures .He also used wrought bars which is equal to the major connectors of cast partial denture.Oval lingual bar and upper flat bars are available for the fabrication of wrought frame work. Scheu has designed an oval lingual bar with H shaped cross section which has improved rigidity and it also provide mechanical under cuts for the resin to lock in to the frame work this bar is called as Profibugel bar . Other design which are used as wrought frame work include oval tapered bar, maxillary clasp bar and mandibular clasp bar which has combination of bar and clasp.

The individual component present in wrought frame work determine the property of the material, the composition of the wrought bar used to rehabilitate in this case is evaluated using plasma emission spectroscopy. The main alloying element being Chromium 13 % , Nickel 0.215% , Silicon 0.370% ,Manganese 0.830% , Carbon of 0.128 % and other trace elements like phosphorous ,sulfur ,molybdenum , Aluminum ,boron, cobalt ,copper ,titanium ,tungsten ,vanadium and the remaining component is of iron

Adaptation of the wrought bar to the contours of the palate and the mandible needs bending with a heavy duty pliers , which will alter the mechanical property . Bending the palatal bar with plier is cold working which will cause strain hardening ,decrease ductility ,and distorted grains this can be reversed simply by heating the metal to an appropriate elevated temperature .This process is called annealing ,the more the degree of cold working the more rapidly the effects can be reversed by annealing . Ingerslev’s method of annealing is raising the temperature up to 375 degree Celsius , raised at the rate of 6.25 degree per minute for 60 minutes and hold at the temperature for 4 minutes and cooled to the room temperature in the furnace .Mongonsin advised the raise of temperature 225 to 425 degree Celsius for adequate time and quenched .Fank advised color index method for annealing of stainless steel .Ingerslev’s method of annealing is followed in this case to relive the stress .The microstructure of palatal bar before annealing shows the grain structure is fibrous in nature ,when subjected to annealing the grain structure shows changes in to coarse grains ,since the stress is relived and the grains are oriented with lesser amount of internal energy, the contour of the palatal bar is maintained for longer duration and increases the serviceability of the prosthesis

#### **IV. Conclusion**

Acrylic dentures will continue to be a successful form of treatment for restoration of edentulous spaces .Good design principles will lead to a well supported denture that reduces any possible harm to the soft and hard tissues. The advantages of acrylic denture is cheap , relatively easy to construct ,easy to modify while the disadvantages are weak material ,non-rigid ,must be bulky for strength ,high potential for damage to soft tissue. the concept of wrought frame work in acrylic partial denture- hybrid denture negates the possible disadvantages of acrylic partial denture, as well as improves the patient comfort and perception which is a psychological boost for the patient.

#### **References**

- [1]. Dental Practice Board, <http://www.dpb.nhs.uk>
- [2]. A.Damien walmsley , Acrylic partial dentures ,Dent Update 2003;30:424-429



**Figure -1**



**Figure - 2**



**Figure - 3**



**Figure - 4**





Figure -5

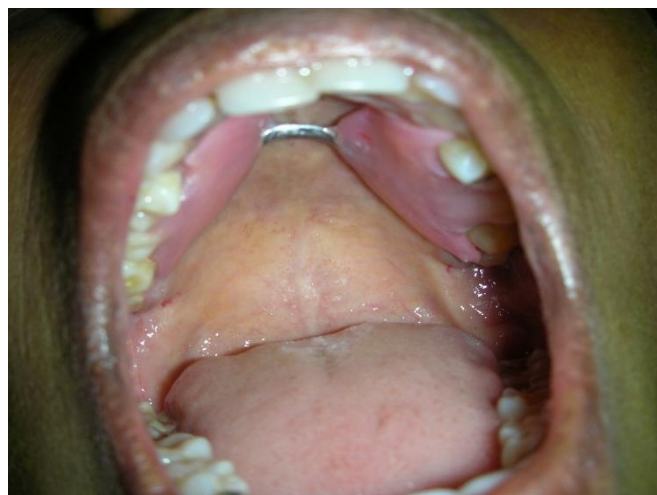


Figure -6

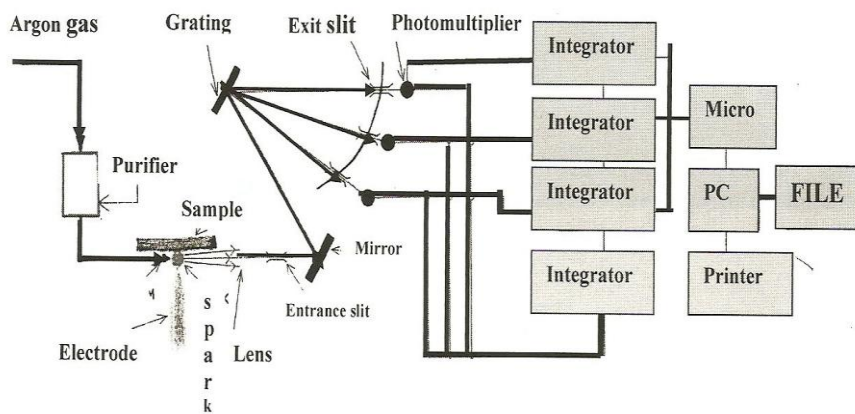
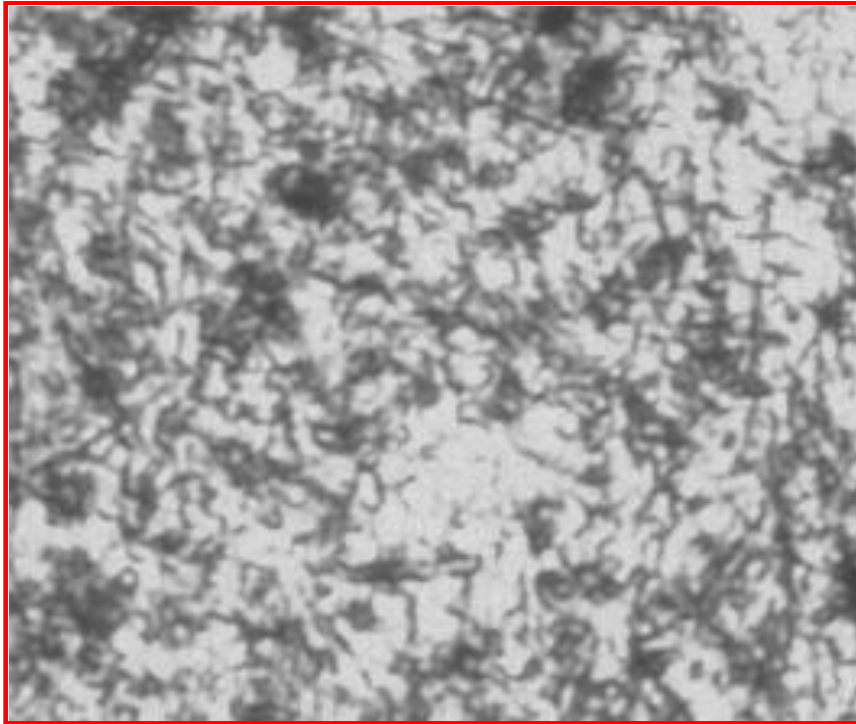
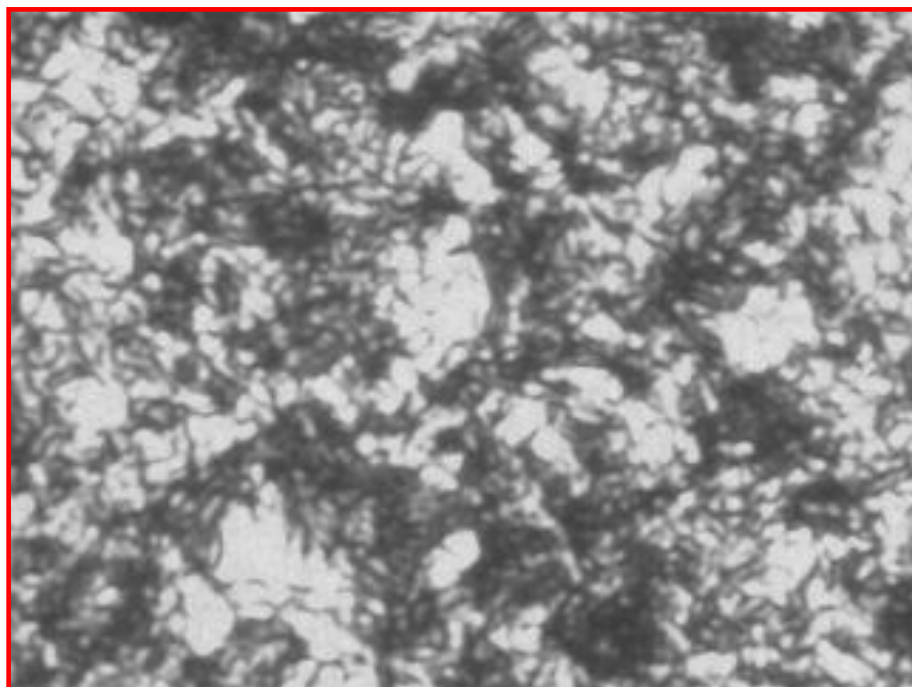


Fig 7- schematic representation of plasma emission spectroscopy



**Fig 8 –Microstructure of stainless steel palatal bar before anealing**



**Fig 9 –Microstructure of stainless steel palatal bar after anealing**

C	0.128
Si	0.370
Mn	0.830
P	0.032
S	0.017
Cr	13.022
Mo	0.022
Ni	0.215
Al	<0.010
B	0.001
Co	0.029

Cu	0.152
Nb	0.036
Ti	<0.010
V	0.029
w	0.068

**Table 1** – Showing the composition of palatal determined by plasma emission spectroscopy

K .Ramkumar. “Characterization and Crystallographic Evaluation of Wrought Stainless Steel Used As Wrought Framework in Acrylic Partial Denture - An In Vitro Study.” IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), vol. 18, no. 2, 2019, pp 31-37.