Microcontroller Based Instrumentation System for Measurement of Strength of Cementing Medium Used in Dental Restorations: Orthodontic Studies

Dinesh Singh Rana

***Abstract*— This paper is concerned with the design of a Micro-controller based Instrumentation system for strength measurement of cementing medium used in dental restorations. A comprehensive analysis of various types of cementing media used to cement various dental restorations such as crowns, bridges etc. are presented. Effects of various cementing media on the retention of dental post in the root canal have been estimated. The system is mainly consists of strain gauges mounted on a cantilever, a specially design amplifier, data acquisition system (ADC0809), Micro-controller (8051) and a display unit. The hardware and software have been integrated into a composite system. The main features of the system are its simplicity, reliability, consistency, cost effectiveness and ease of use.**

***Index Terms*— ADC, Endodentic post, Root canal, Strain gauge, Zinc phosphate cement, Zinc polycarboxylate cements.**

I. INTRODUCTION

Modern endodentic therapy has shown highest rate of success. A dental restoration or dental filling is a dental restorative material used to artificially restore the function, integrity and morphology of missing tooth structure. The structural loss typically results from caries or external trauma [5, 6]. It is also lost intentionally during tooth preparation to improve the aesthetics or the physical integrity of the intended restorative material. Dental restoration also refers to the replacement of missing tooth structure by restoring dental implants. It is usually happen many times due to accidents that a person looses tooth/ teeth with root intact. For cosmetic reasons it is necessary to provide a crown for the root. The preservation of many teeth which have little or no remaining clinical crown require a dowel and core to replace the lost tooth structure. This achieved by means of post cementation into the root canal. This procurement of cementation cans approximately double the strength of the root. A crown can then be fabricated over it as illustrated in Fig. 1.

The retention of post crown is influenced mainly by two type factor; Post factor and Cementation factor. The post factor includes the post length, diameter, shape etc.. Inadequate length of dowel is probably the leading cause of failure of endodentically restored teeth [2, 5, 6]. The different shapes of dowel are used by dentists, but present studies have been made with tapered dowel. This in turn can be inserted or filled into the root canal. The developed Instrumentation system greatly helps in study the combined effects of the length of the post and the cementing medium on the retention of endodontic post.

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D.S. Rana is with the Institute of Instrumentation Engineering, Kurukshetra University, Kurukshetra-136119 India
phone: and fax: +91-1744-238191; +919466045776(M)
e-mail: dineshsrana24@rediffmail.com

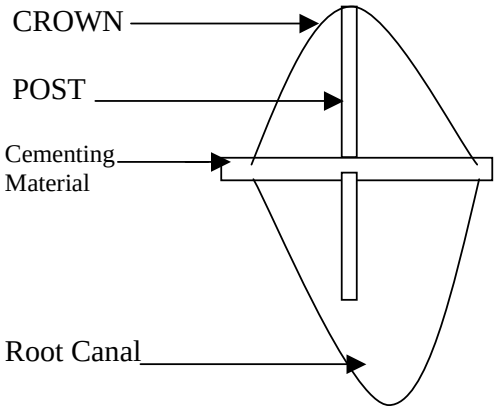

Fig. 1. Restored Tooth Structure

The Microcontroller based Instrumentation system for the measurement of strength of cementing media used in the above studies is illustrated in Fig.2.

II. INSTRUMENTATION SYSTEM

The Instrumentation system consists of the followings:

- Two strain gauge mounted on a mild steel cantilever and two resistances each of 120Ω are arrange in Wheatstone bridge configuration as illustrated in Fig.. 3
- Signal conditioning system
- 8051 Microcontroller
- Display system
- Power Supply Unit

In the developed Instrumentation system two strain gauges both active are cemented on the opposite surfaces of the cantilever. In this configuration the gauge on the top face of cantilever experiences a positive strain and other gauge mounted on opposite face of cantilever experiences a negative strain. The sensitivity of this half bridge configuration is twice to the sensitivity of a quarter bridge arrangement.

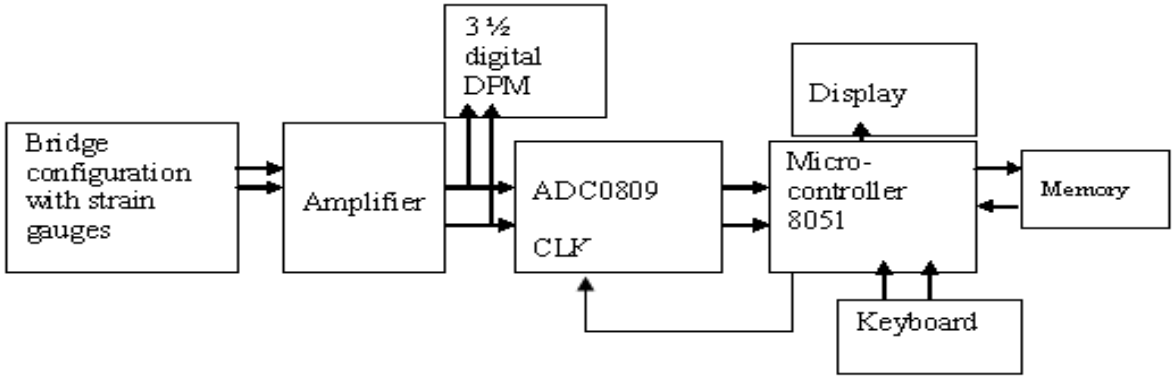

Fig. 2. Illustration of the Microcontroller based instrumentation system for orthodontic studies

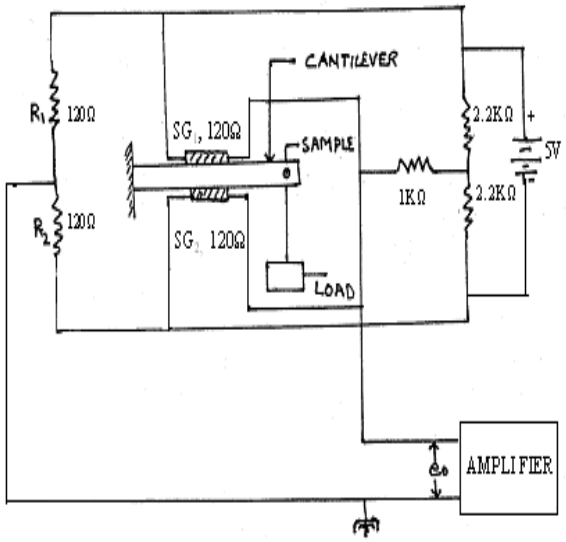

Fig.3. Wheatstone bridge configuration

A. SIGNAL CONDITIONING SYSTEM:

The signal conditioning system consists of amplifier and ADC0809.

The output signal obtained from the bridge is of low magnitude and hence needs to be amplified before further processing.

The designed amplifier using op07 Ics with bridge configuration block is illustrated in Fig. 4. This amplifier has provided adjustable gain arrangement to keep its output in the range of '0' to 5 volt, which is required for the input of analog to digital converter (ADC0809) for further processing of signal. An ADC0809, (Fig.5.) analog to digital converter is used in present design which has inbuilt 8- channel multiplexer and 8 bit successive approximation type analog to digital converter (conversion time 100μs). The ADC0809 is directly interfaced to the 8051 Microcontroller. The Signal flow graph for the analog to digital conversion is shown in fig. 6. The following are the steps to get data from analog input of ADC809 into the Microcontroller [1, 3].

1. Select an analog channel by providing bits to A, B, C addresses.
2. Activate the ALE pin. It needs an L-to-H pulse to latch in the address.

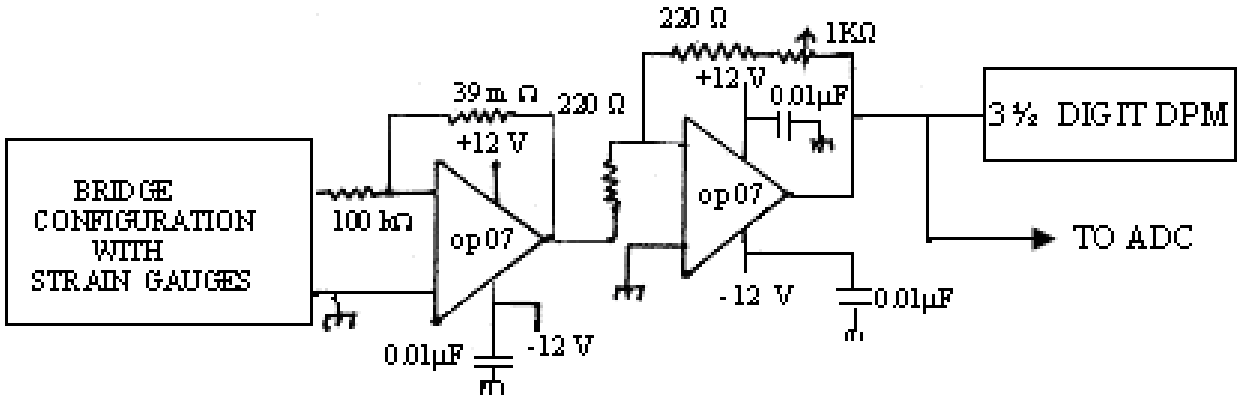

Fig. 4. Amplifier circuit with bridge configuration block of strain gauges

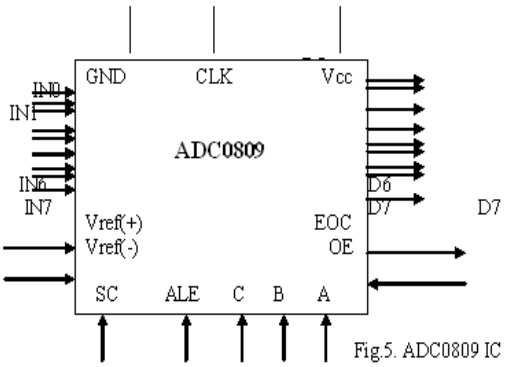

Fig.5. ADC0809 IC

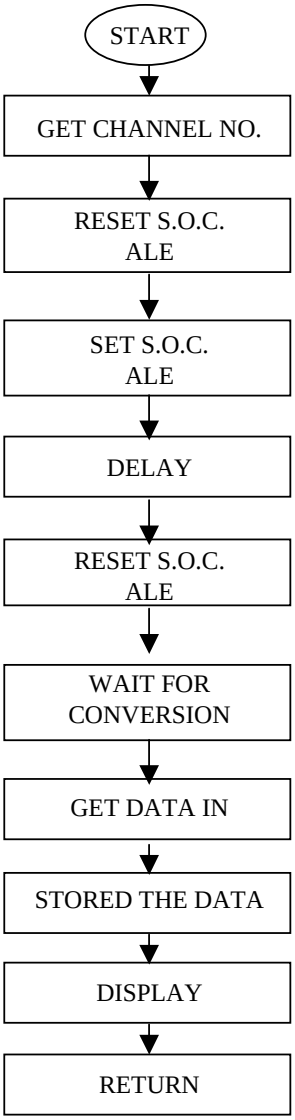

Fig. 6 : Signal Flow graph

3. Activate SC (start of conversion) by an H-to-L pulse to initiate conversion.
4. Activate OE (output enable) to read data out of ADC0809. An H-to-L pulse to the OE pin will bring digital data out of the ADC0809 chip. External clock must be provided to the CLK pin of ADC0809.
5. Make port 1 of the Microcontroller as input port (pin 1 through 8) and then the data is received from that port and monitored on seven segment display

B. POWER SUPPLY UNIT:

A compact DC power supply is in-built in the Instrumentation system Detail circuit of the fabricated power supply is illustrated in Fig.7. Following components are used in power supply circuit; Regulator Ics 7812, 7912, 7805, Transformer 15- 0-15,1Amp 1N4002 diodes and 0.47μf capacitors.

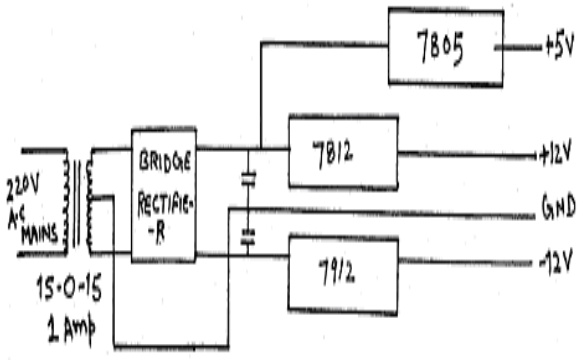

Fig. 7: Power supply circuit configuration

III. RESULTS AND ANALYSIS

Twenty four maxiallary central incisors were chosen for the present study. They were divided into three groups of eight teeth each. Three length of post 7mm, 9mm and 11mm were chosen for the study. Each of three groups further divided into two sub groups of four teeth depending on the type of cementing medium used. First sub groups had posts cemented with Zinc phosphate cement and second sub group had cemented with Zinc polycarboxylate cement. The group classification of twenty four maxiallary central incisors is illustrated by fig.8. In first sub group, four teeth each are associated with post length 7mm, 9mm and 11mm were cemented with Zinc phosphate cement respectively and for second group, four teeth each are associated with post length 7mm,9mm and 11mm were cemented with Zinc polycarboxylate cement respectively. The posts were cemented into the root canal and then subjected to retention testing. Table-I & Table-II gives a comparative study of measurement of strength of cementing material used in dental restorations as the result of testing. The mechanical strength of the cement is indirectly measured in term of the force required to dislodge the post from root canal. The force required to

dislodge the post from root canal for the different post length (7mm, 9mm, 11mm) cemented with zinc phosphate cement is maximum for the post length of 11mm i.e.; 11.5 Kg weight is required to dislodge the 11mm long post from root canal. Similarly, the value of maximum retention for the 9 mm post is 7.75 Kg and that of 7mm post is 6.25 Kg when cemented with zinc phosphate cement. The maximum retention for the different post length of 11mm, 9mm and 7mm are 7.5 Kg, 5.75 Kg and 4.5Kg respectively when cemented with Zinc polycarboxylate.

IV CONCLUSIONS

In this paper, an analysis of the situation existing in dental restoration in respect of Instrumentation system has been made. It is found from the observation Table-I & Table-II that the retention increased with increase in the post length. Cementing material Zinc phosphate gives higher retention values as compare to the Zinc polycarboxylate. Maximum retention was obtained by 11mm post cemented with Zinc phosphate cements. The influence of different cements on post core retention is related to their mechanical properties, adherence capacity to metal and dentine and their durability. The design Instrumentation system has been successfully used in orthodontic studies for strength measurement of cementing medium used in dental restorations.

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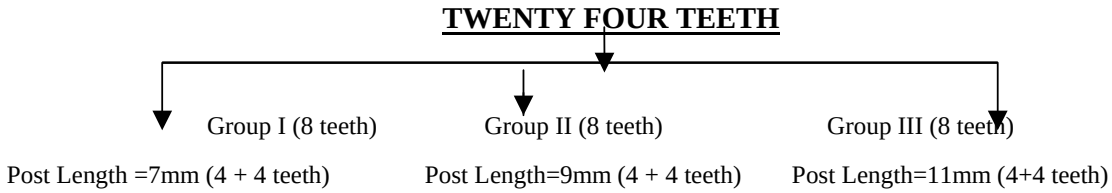

Fig. 8. Group classification of twenty four maxiallary central incisors

Table-I:

[Force (in kg, volt, Hex) required to dislodge the post Cemented with Zinc phosphate]

Kg Post length=7mm	volt	Hex	Kg Post length=9mm	Volt	Hex	Kg Post length=11mm	volt	Hex
5.5	1.5	4D	7.25	2.2	75	11	3.7	CA
6.25	1.8	6E	7.5	2.3	7A	11.5	3.9	D6
6.0	1.7	5A	7.75	2.4	80	11.25	3.8	D0
5.75	1.6	59	7.5	2.3	7A	10.75	3.6	C6

Table-II

[Force (in kg, volt, Hex) required to dislodge post Cemented with Zinc polycarboxylate]

Kg Post length=7mm	volt	Hex	Kg Post length=9mm	volt	Hex	Kg Post length=11mm	volt	Hex
4.0	0.9	2B	5.25	1.4	4A	7.5	2.3	7A
4.25	1.0	31	5.5	1.5	4D	7.0	2.1	6E
3.5	0.8	26	5.75	1.6	59	6.75	2.0	68
4.5	1.1	36	5.25	1.4	4A	7.5	2.3	6E