NON-INVASIVE MEASUREMENT OF STRESS LEVELS

IN KNEE IMPLANTS

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Abstract - *Total knee replacement is an operation frequently needed by hemophiliacs patients, which greatly improves their quality of life. This operation, however, carries a higher risk of bleeding and infection for hemophiliacs than it does for osteoarthritis sufferers. It is advisable to implant prosthetic components using antibiotic-loaded cement. It is essential to maintain a level of 100% of the replacement clotting factor for 2 weeks. Haematological treatment must be established, depending on the patient's factor levels and other pharmacokinetic parameters such as recovery and half-life, optimal doses and treatment time. The lifespan of total knee replacement in haemophilic patients is shorter than in patients with osteoarthritis because of the increased risk of infection. The biomechanics of the knee joint provide an important basis for the rationale in the design and selection of appropriate total knee arthroplasty. This article examines knee biomechanics in terms of patient function, prosthesis design, cruciate ligament retention, alignment, and fixation of the tibial component. While design and surgical technique for total knee replacement progress, a better understanding of the characteristics of joint loading, stress distribution, and the biologic response of bone to stress will provide the potential to improve both function and implant longevity.*

*Key Words***:** Hemophiliacs, Osteoarthritis, Noninvasive sensors, Wearable criss-cross sensors.

1. INTRODUCTION

Now a days the people are facing lot of knee problems due to the lack of Bone Mineral Density. In human body knee is one of the important and complex structure and that cause a human can not even stand properly without this knee joint. While walking, playing, jumping, etc., we are applying lot of pressure on knee that causes high pressure on the knee which may leads

for knee replacement also known as Total knee arthroplasty. It is a medical procedure to replace the weight-bearing part of the knee joint to relieve pain and disability. The Total Knee Arthroplasty is beneficial and proven that it is successful. It is most commonly used treatment for osteoarthritis these days. This surgery is bit complex contains extensive pre-operative planning, specialized implants and tools, prolonged duration. It takes longer time to perform than the normal knee replacement. Even this treatment is difficult when the patient is very old. The main scope of this project is to help the knee patients by developing a hardware including multiple sensors to monitor the pressure and stress which is applied to the implant. The sensing elements which are hermetically sealed on kneecaps are used to track the flexibility, direction, and temperature. It is difficult to check the internal problems of the knee after implantation so there are few traditional methods to maintain the knee implant like timely check-ups and invasive chips but the present Existing solutions are invasive and very time consuming or may lead to infections if we neglect.

1.1.   SCOPE OF THE PROJECT

The main scope of this project is to help the knee patients by developing a hardware including multiple sensors to monitor the pressure and stress which is applied to the implant. The sensing elements which are hermetically sealed on kneecaps are used to track the flexibility, direction, and temperature. It is difficult to check the internal problems of the knee after implantation so there are few traditional methods to

maintain the knee implant like timely check-ups and invasive chips but the present Existing solutions are invasive and very time consuming or may lead to infections if we neglect.

1.2. OBJECTIVE OF THE PROJECT

The goals of total knee replacements (TKR) are to help assure a stable, pain-free knee with which the patient is happy. These goals include the following:

- Recreating limb alignment and a neutral mechanical axis so that weight-bearing forces are nearly equalized between the inner and outer compartments of the knee. This also has the effect of straightening any pre-TKR bowlegged or knock-kneed angulation.
- Balancing the soft tissue sleeve that surrounds the knee so that as the knee moves from extension to flexion, equal and physiologic tensions or pressures are experienced in the medial and lateral ligaments.
- Creating normal knee movement (kinematics) as the knee ranges from extension into flexion and then back to extension. Normally, as the knee flexes, the tibia internally rotates and the femur pivots on the inner or medial compartment. During extension, this normal rotation or pivot reverses and the tibia externally rotates. The cruciate ligaments as well as other soft tissues and the shape of the bones help to control this normal complex movement.

1.3. LIMITATIONS OF THE PROJECT

- A replacement knee can never be quite as good as a natural knee – most people rate the artificial joint about three-quartersnormal.
- Most knee replacements aren't designed to bend as far as your natural knee. Although it's usually possible to kneel, some people find

it uncomfortable to put weight on the scar at the front of theknee.

- Clicking or Clunking in the kneereplacement.
- Numbness at the outer edge of the scar.
- A replacement knee joint may wear out after a time or may becomeloose.

1.4. HARDWARE REQUIREMENT

SL.NO	COMPONENTS NAME	Nos.
1	Force sensor	1
2	Flex sensor	1
3	ADC	1
4	Microcontroller	1
5	IOT	1
6	Buzzer	1
7	Power supply unit	1

Table 1: Components list

1.4.1. FORCE SENSOR

One of the most affected components of the artificial knee implant is the ultra-high-molecular-weight polyethylene (UHMWPE) insert, due to its geometry and the high forces acting upon it. Therefore, monitoring the strain, associated with knee imbalance and forces acting upon the prosthesis, can give continuous feedback on the status of the artificial knee implant. Strain gauge sensor is used for the monitoring of loads acting upon an artificial in knee implants.

1.4.2. FLEX SENSOR

This flex sensor usually measures the amount of bending position that object reflects in their working period (deflection) This flex sensor re fixes the bone

to the original position when it is resembles that the fractured bone is moving from the desired part where it is fixed in criss cross method to locate the bone in the condition for shorter duration of recovery of bones fractures which is compatible.

1.4.3. ANALOG TO DIGITAL CONVERTER

An Analog to Digital Converter (**ADC**) is a very useful feature that converts an analog voltage on a pin to a digital number. By converting from the analog world to the digital world, we can begin to use electronics to interface to the analog world around us. **ADCs** can vary greatly between **microcontroller**. The digital output varies from 0-255. ADC needs a clock to operate. The time taken to convert the analog to digital value depends on the clock source. An external clock can be given to CLK IN pin no.4. A suitable RC circuit is connected between the clock IN and clock R pins to use the internal clock. Pin2 is the input pin – High to low pulse brings the data from internal register to the output pins after conversion. Pin3 is a Write – Low to high pulse is given to external clock. Pin11 to 18 are data pins from MSB to LSB.

1.4.4. MICROCONTROLLER (ARDUINO UNO)

The Arduino Uno is a development board based on the ATmega328 microcontroller having 14 Digital I/O pins(can generate 6 PWM output) and 6 Analog input pins and it works with 16 MHz crystal Oscillator. This board will work with 5v supply which we can provide with adopter/Battery. Arduino Uno is very flexible to program as it has its own IDE called Arduino IDE. As we know that Arduino is a family having different types of development boards with different microcontrollers, we need to select the board and write the code accordingly. Arduino IDE is an open source so that we can download it from the internet. Arduino microcontroller and IDE are shown below. Arduino Uno is an Open source Microcontroller comes with preprogrammed with a boot-loader that allows uploading new code to it without the use of an external hardware programmer. Generally, It communicates using the original STK500 protocol. Rather than requiring a physical press of the reset button before an

upload, the Arduino Uno board is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nano farad capacitor. With the help of this line, we can restart the development board through software.

1.4.5. IOT

When the system is wireless wearable techniques then GSM module plays an important role as it takes the data from the external surface by IOT method. When surgeon or physician is non contact to the patient in emergency situation . The GSM module helps the connectivity between internal (patient) and external (physician) for the consulting purposes.

1.4.6. BUZZER

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke. A buzzer is in the mechanical form of a small rectangular or cylindrical housing, with electrical connection for direct mounting on rigid printed circuit, or with electrical connection consisting of flexible electrical son. In the latter case, the buzzer has two small brackets. The loudness of such a component is about 85 dB / cm (note that it does not specify the sound level meter - as for HP, as a business perspective, it would seem probably too little power.
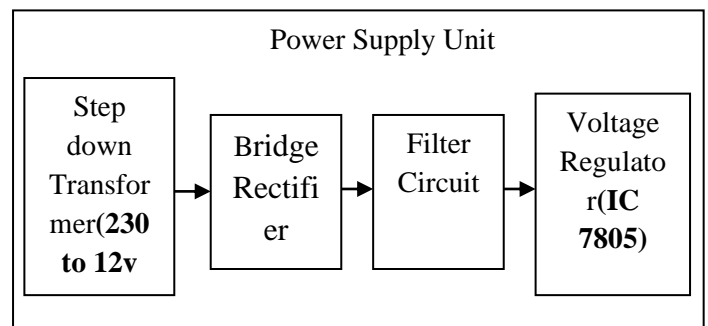
1.4.7. POWER SUPPLY UNIT

Figure 1 : power supply unit

2. PROPOSED MODELLING

Our proposed system is a cost-effective and non-invasive method to detect the stress levels at knee implant. By using the flex sensor, pressure sensor, and temperature sensor we can monitor the knee implant continuously which are included in this current proposed solution (kneewear). In our proposed system Flex sensor, Pressure sensor &Temperature sensors will be connected in the knee wear to measure the data at knee implant and send the output in analog format. These sensors will monitor and detect the problems like overpressure, high Temperature and over bending of the knee plant and the data will be sent to the Microcontroller Arduino. Here the Arduino can receive the analog data from the sensors and convert the data into digital as Arduino is built up with internal ADC. The data will be compared with the programmed values. if the sensor values are more than the specified values that means the pressure/temp/force is high at the knee implant then the controller immediately indicates the patient with a warning buzzer and enables the LCD to display the problem level so that the patient will get to know what is happening at the knee implant. Simultaneously the microcontroller will initiates the GSM module to send the sensor data and problem levels to the concerned people like doctor nearest caretaker. In this GSM module will be controlled using the AT Commands which are already programmed in Arduino. This Communication will be initiated first then the required data can be transferred as per the problem level. This entire equipment is powered with power supply board as we need to provide different voltages for different modules we need to provide the different supply voltages. Power supply unit/board will help us to power up the entire unit with different voltages. In this equipment, we have to take care of powering up the modules cause these modules may get damaged with the higher voltages.

- With our proposed system we can improve the success rate of knee implant treatment/surgery.
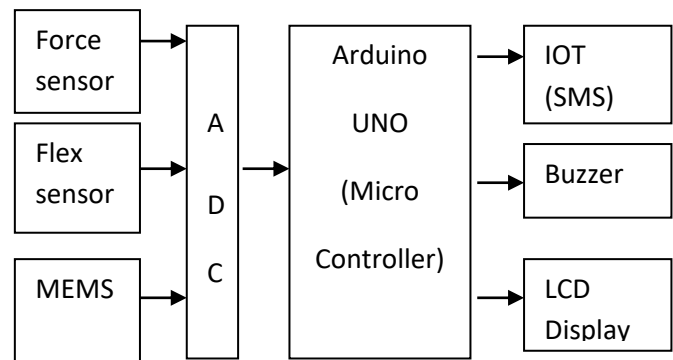- We can avoid the timely check-ups

Figure 2: Architecture of Device

3.RESULT

WEIGHT LAID (in kg)	FORCE SENSOR OUTPUT (millivolt)
0	0
2	32
5	60
7	85

Table 2: force sensor output with respect to weight laid

ANGLE BENT (in deg) (approximately)	FLEX SENSOR OUTPUT (millivolt)
0	180
15	311
30	425
45	612
60	746
75	865
90	1029

Table 3: flex sensor output with respect to angle bent

4. CONCLUSION

In major cases, the knee implantation is failing because of lack of care after knee implantation. Here we can overcome this failure with our proposed system which helps to monitor the patient's implant continuously with multiple sensors like Flexibility, Temperature & Pressure sensors. The most probable cause of premature implant failure is aseptic loosening, which is

a severe physiological response to foreign debris in the joint. This debris is generated from abrasive wear in the ultra-high molecular weight polyethylene (UHMWPE) of the tibial insert, due to mal-positioning of the articular surfaces and the high forces acting in the joint. Therefore, effective monitoring of the temperature, force and flex within the UHMWPE insertan provide real-time caution on the condition of the knee implant to the patient. In our proposed hardware, we are using GSM modules for long distance communication so that we can send the alert notifications to the concerned caretaker and physician for instant help/treatment. With this equipment, we can reduce the problems of knee implantation.

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