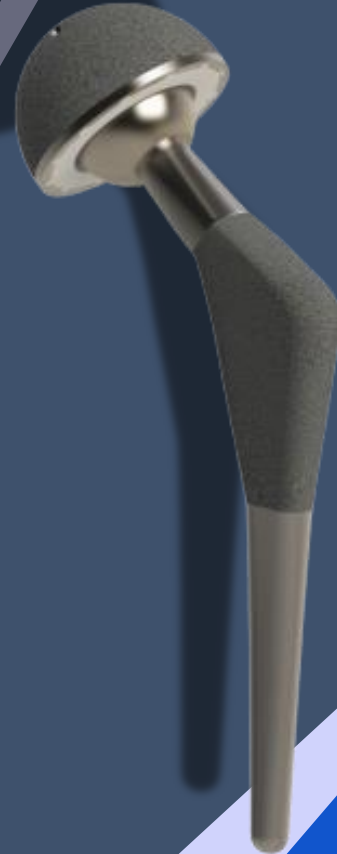


# Prosthetic Hip Implant

Group 5

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# Outline

## Introduction

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Objectives  
Evolution of the Hip Implant  
Gaps in Current Technologies

## Our Design

Stem  
Head  
Cup  
Liner

## Stress Analysis

Beam Theory  
Fatigue  
Wear

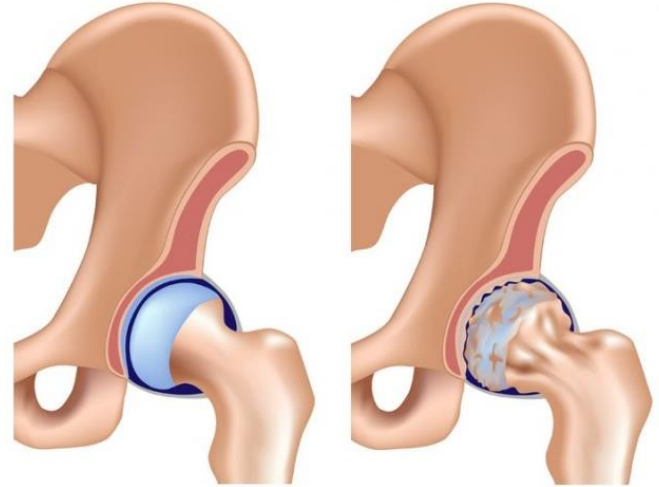
# Introduction

## Causes of THA

- Arthritis
- Bone Necrosis
- Osteoporosis

## Prevalence

- 51% women, 24% men = 250,000 fractures annually (USA)
- 10% due to osteonecrosis
- Higher in women than in men



Healthy hip joint

Osteoarthritis

## ► Objectives/Motivation



### Typical Patient

- Elderly (70+)
- Female
- Mildly active lifestyle
  - 5000 steps/day



### Objectives

- Address gaps in current technology
- Provide a stable, long lasting hip implant

## ► Evolution of the Hip Implant

### 1891

- Ivory
- Nickel-plated screws

### 1953 - 1960

- First use of metal-on-metal
- First use of poly-on-metal

### Current

- Variety of bearing combinations
- Highly biocompatible materials
- 15-20 year lifetime

## ► Gaps in Current Technology

- **Wear leading to Osteolysis**

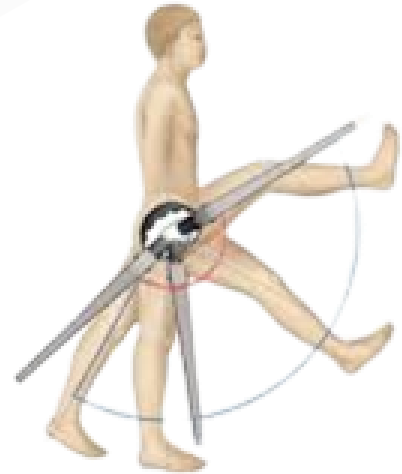
Causes implant to loosen and fail

- **Stress Shielding**

Implant takes too much stress and bone resorbs

- **Limited Range of motion**

Femur dislocation



## ► Design Requirements and Criteria

### Requirements

- Maintain ROM
- Avoid dislocation
- Reduce friction
- Reduce noise
- Biocompatible
- Ease of imaging
- Maximize lifetime

### Criteria

- <\$50,000
- <2kg mass of implant
- For patients:
  - >100lbs, <240lbs
  - >5'0", <6'4"

# Our Design

Stem

Head

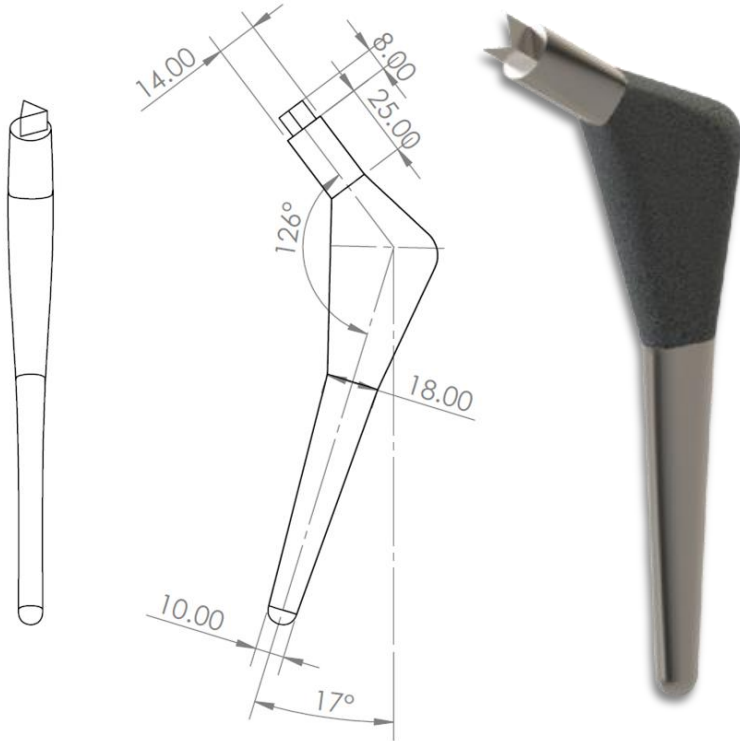
Liner

Acetabular cup





## ► Femoral Stem



### ► **Ti-6Al-7Nb**

- Young's modulus similar to bone
- Biocompatible
- Non-magnetic (MRI)

### ► **Cemented (2mm thick)**

### ► **Triangular press fit into head**

### ► **Coating: Curcumin and antibiotic hydrogel coatings**

### ► **Slightly shortened stem**

### ► **Eccentricity to match trabecular bone**

## ► Femoral Head

### ► Shape

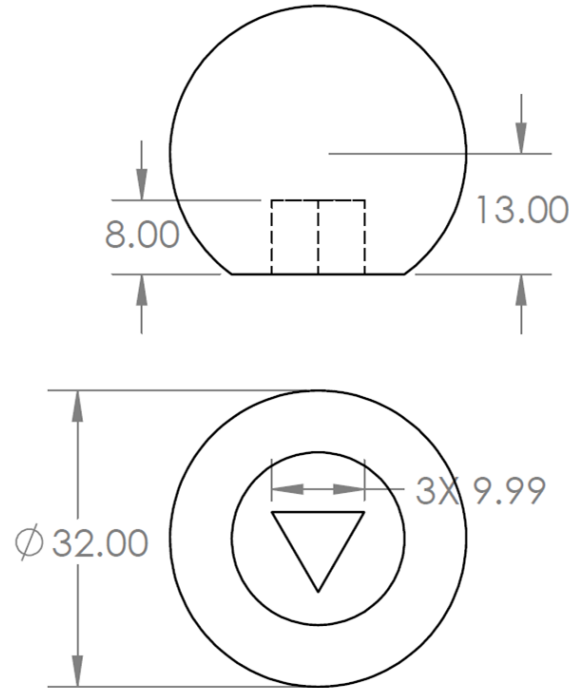
- Articulates within acetabular liner
- 32mm diameter

### ► Triangular Slot

- Press fit onto femoral neck
- Prevents rotation

### ► Co-Cr-Mo

- Wear resistant
- Biocompatible
- Corrosion resistant



## ► Acetabular Liner

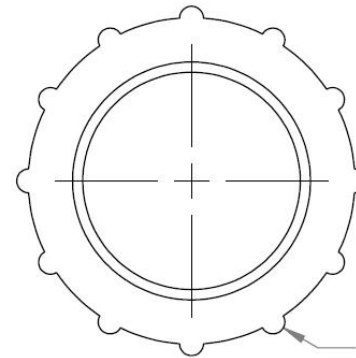
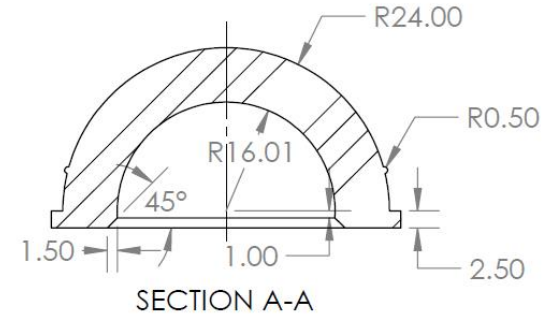
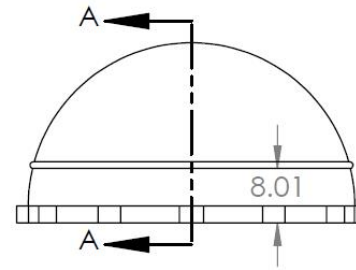
### ► XLPE

- High strength
- Shock absorbing
- Enhances stability

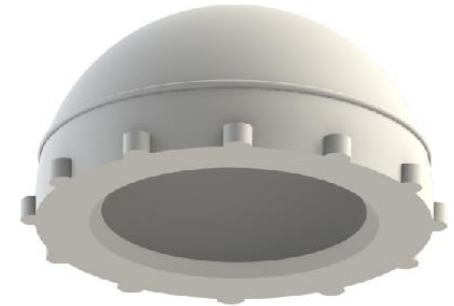
### ► Design features

- Chamfer
- Flaps to stop spinning
- Ring to lock liner in place

### ► Curcumin coating

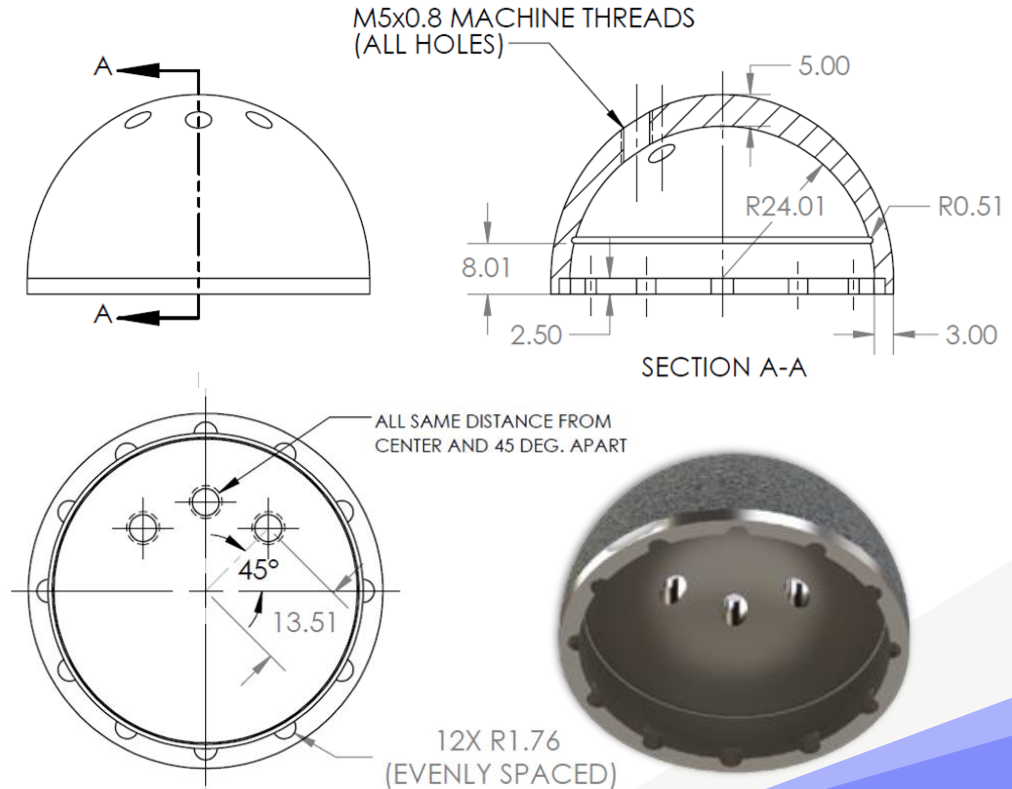


12X R1.75  
(EVENLY SPACED)

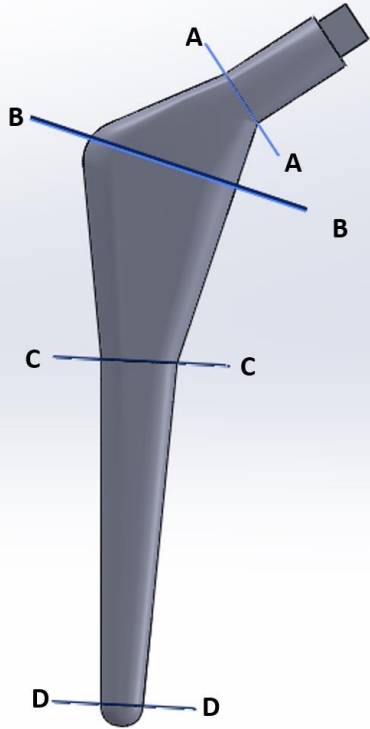


## ► Acetabular Shell

- **Cemented (2mm thick)**
- **Ti-6Al-7Nb**
  - Young's modulus similar to bone
  - Biocompatible
  - Non-magnetic (MRI)
- **Non uniform thickness**
  - Optimizes fatigue stress
    - Reduces stress shielding
    - Prevents loosening



# Stress Analysis



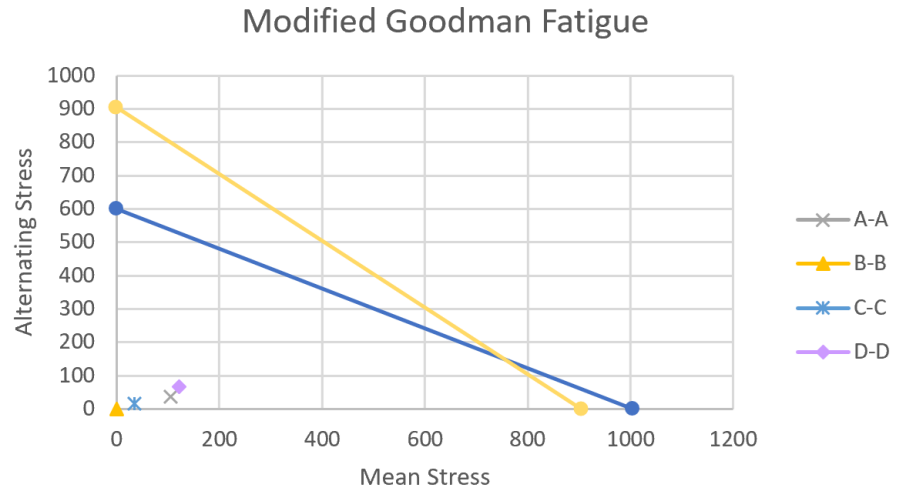
Safety Factors	A-A	B-B	C-C	D-D
Natural Cortical Bone	-	35	22	2.1
Cortical Bone with Implant	-	128	22	2.9
Implant	4.4	338	32	7.6
Cement	-	1457	31	5.3

Hertz Contact Stress	Safety factor
CoCr	6.4
XLPE	4.2

Stress Shielding	B-B	C-C	D-D
Stress shielding ratio	3.5 (72%)	1.8 (45%)	1.4 (27%)

## ► Fatigue Analysis

- Cyclic loading during walking
- Stresses occur in the femoral stem
- Alternating and mean stresses
  - Minimum force while laying down
  - Maximum force while walking
- All cross-sections show infinite life

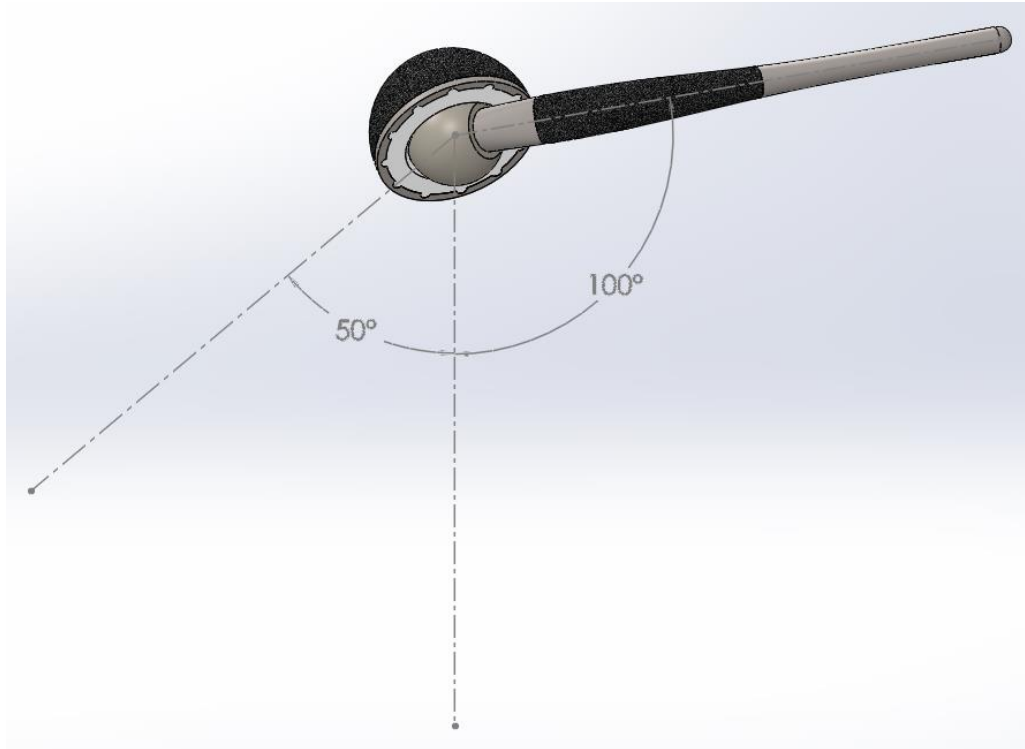


## ► Wear Analysis

- XLPE liner against the Co-Cr femoral head
- Function of distance, force, Brinell hardness
- Worst case scenario:
  - 10 million passes
  - Maximum arc length distance
- Wear volume equivalent to a 3.4mm cube



## ► Sagittal Plane Range of Motion



Flexion → 100°

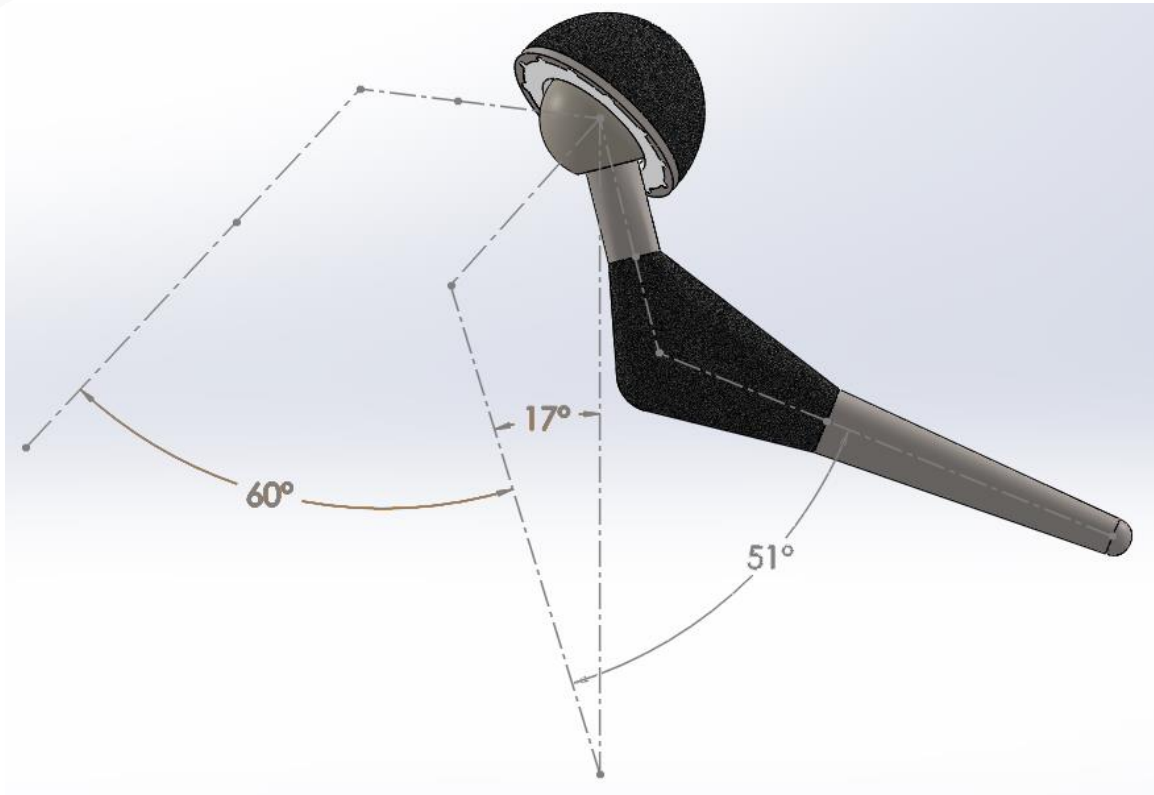
Extension → 50°

Typical flexion ROM of a 55-86 y/o is  $109^{\circ} \pm 19^{\circ}$  flexion

Female passive extension ROM is  $\sim 26^{\circ}$



## ► Frontal Plane Range of Motion

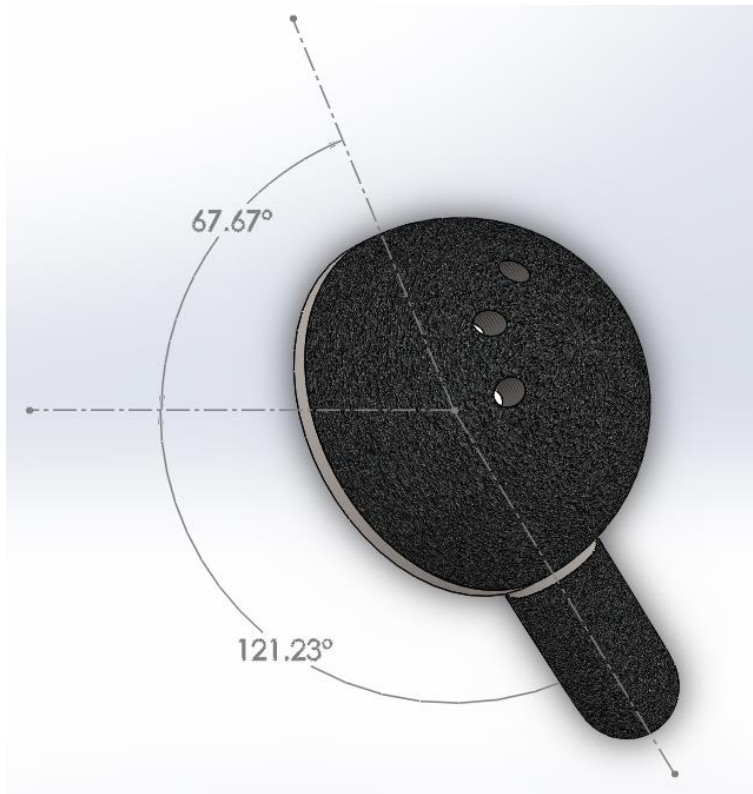


Adduction  $\longrightarrow$  51°  
Abduction  $\longrightarrow$  60°

Female passive ROM:

- 30° adduction
- 42° abduction

## ► Transverse Plane Range of Motion



Internal rotation  $\longrightarrow 121.23^\circ$   
External rotation  $\longrightarrow 67.67^\circ$

Prosthetic ROM  $\gg$  Anatomical ROM

## ► Features and Contributions

### **Curcumin Coating**

To reduce osteolysis  
from debris

### **Removable Liner**

For easy replacement

### **Non Uniform Cup**

To prevent stress  
shielding and cup  
loosening

### **Eccentric Implant**

To mimic trabecular bone

### **Cemented**

Elderly, no bone in-  
growth

### **Antibiotic Hydrogel**

To prevent infection



**Thank you**

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