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Does All Burr Robotic Assisted Total Knee Arthroplasty Causes Early Aseptic Loosening Due to Thermal Osteonecrosis

*** Dr. Mukesh Laddha (DNB, D. Orth)**

Robotic Joint Replacement and Arthroscopy Specialist (Shoulder, Knee and Hip Surgeon)

RNH hospital, Balraj Marg, Near Dhantoli Garden, Dhantoli, Nagpur-22, Maharashtra, India

drmsl1812@gmail.com / dr.msl@rediffmail.com, Contact Number - 9372635385

Dr. Prakhar Jain (D.Ortho)

Fellow in Joint Reconstruction

RNH hospital, Balraj Marg, Near Dhantoli Garden, Dhantoli, Nagpur-22, Maharashtra, India

drprakharj@yahoo.in, Contact Number - 8806217002

Dr. S. V. Goutam (M. S. Orthopaedics),

Fellow in Joint Reconstruction

RNH hospital, Balraj Marg, Near Dhantoli Garden, Dhantoli, Nagpur-22, Maharashtra, India

svgoutam70@gmail.com, Contact Number - 8892994586

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Abstract

Aim:

It’s a well-known fact that heat generated from high power orthopaedic trauma tools causes thermal osteonecrosis leading to early loosening and implant failure. So, the aim of our study is to prove that all burr robotic assisted TKA does not result in early aseptic loosening or failure due to thermal osteonecrosis.

Keywords-robotic knee replacement, thermal osteonecrosis, all burr, aseptic loosening, knee replacement

Introduction:

Total knee arthroplasty (TKA) is currently the most promising and successful treatment for patients with end-stage knee osteoarthritis [1].TKA had demonstrated success rate between 91% and 98% at 10 to 26 years[2]There are three ways to do TKA namely conventional, navigated and robotic assisted [3]Reasons for the failure of TKA are multi factorial like poly wear, bad bone preparation, bad cementing, malposition of components, instability, lack of bone coverage, infection, etc [4]It's a well-known fact that high power orthopaedic tools causes bone damage due to tremendous heat generation from drill or burr causing thermal osteonecrosis leading to early loosening and implant failure [5,6].Similarly in Robotic assisted all burr TKA, heat generation leads to osteonecrosis as per study done in bovine [7,8]. So far to the best of our knowledge no in-vitro study had been done to prove whether this thermal osteonecrosis by all burr leads to early aseptic component loosening.

So, the aim of our study is to prove that all burr robotic assisted TKA does not cause early loosening or failure due to thermal osteonecrosis.

Method and materials:

This is a retrospective study done on 30 knees operated between December 2018 to June 2019. Total 17 patients (30 knees) were involved, 7 males and 10 females with a mean age of 67years. Patients with grade IV osteoarthritis of knee underwent All Burr Robotic Assisted TKA at RNH Hospital, a recognised Centre for Robotic Joint Replacement and Sports Medicine. All patients were operated by senior surgeon (MSL) using Navio Robotic System. Inclusion criteria were primary and secondary osteoarthritis of the knee operated in that period of time. Exclusion criteria were revision knee replacement, partial knee replacement and conventional TKA. Preoperatively all patients underwent standard anteroposterior and lateral knee radiographs along with weight bearing scanogram. Postoperatively all patients underwent radiographic screening on 1^{st} ,3^{rd} and 28^{th} month.

All the patients were operated by using a medial para- patellar approach. The NAVIO robotics-assisted surgical system involves handheld robotics with an intuitive CT-free registration and patient-specific planning processor. The NAVIO software guides surgeon in creating implant plan that localises components and balance soft tissue and using handheld instrument with multiple control modes to help the surgeon to precisely create 3D model of bone for implantation

of tibial and femoral components. The system tracks the patient's limb and the hand-held high-speed milling or burring tool attached to its arm of 5 mm diameter, stopping or retracting the burr to keep the surgeon within the defined limits of the implant resection. This burring system generates tremendous amount of heat So, to prevent thermal osteonecrosis internal water-cooling and continuous irrigation is integrated into the milling tool to prevent thermal osteonecrosis. The resected surface of bone is as flat as obtained after saw cut-provided burr is used properly in circumferential manner. The digital angel is then used to recheck the cut surface. After completing milling, trial implants were placed, and soft tissues were balanced. The final components were then inserted manually after cement application.

To assess aseptic loosening and radiolucent lines below tibial and femoral component, we have used a modern system approved by the Knee Society membership, which ensured proper radiographic documentation of coronal and sagittal implant alignment, fixation interface integrity with respect to radiolucent lines and osteolysis, and a zonal classification system to document precise deficiency locations. Data was analysed by Meneghini Modern Knee Society Radiographic Evaluation System (figure 1) for implant risk "criteria" or "scores' [9].

Results:

Out of 30 cases only two cases showed asymptomatic radiolucent line(ARL), one in tibia and one in femur (table 1).Similarly out of the 30 cases none had showed ARL at mean follow up of 28.9 month (Fig 2) except in two patients of which one patient had femoral component ARL seen in zone 3a and in another patient ARL was seen in tibial component in zone 1(Fig 3). This is not of significance as p value is 0.609 (table2)

Discussion:

Total knee arthroplasty (TKA) is currently the most promising and successful treatment for patients with end-stage knee osteoarthritis around the globe [1]. Aseptic loosening is one of the most common cause for failure of TKA. The National Joint Registry (NJR) from England, Wales, Northern Ireland and the Isle of Man reported 35.0% of all single stage revision TKA were due to aseptic loosening[1].Material properties of implants, bearing surface, fixation method, implant modularity, osteonecrosis, etc are the important factors related to the development of aseptic loosening.[2]

Osteonecrosis or bone death can occur due to heat generated from high powered orthopaedic tools [5]. Currently, it is agreed that bones exposed to temperature of >47°C for 60 seconds or

longer are at risk of osteonecrosis [6]. This leaves the implant exposed to necrotic tissue, reducing bone-implant incorporation, as well as healing processes [7,8]. Although thermal osteonecrosis has been well described in literature most studies are drill based, as drills are the most commonly used tool in orthopaedics and dentistry; a field where thermal osteonecrosis is a prominent problem [10,11,12]. As bone drilling is a significant part of routine orthopaedic and trauma surgery so heat generated with drill causes osteonecrosis and this is one of the reason for aseptic loosening of plate fixation [13,14]. Robotic computer assisted surgical devices favour the use of a burr over a saw blade for bone resection, as burrs provide more accurate bone preparation than saws. As these devices are newly developed, little research has been carried out into the effects of burring on bone. The amount of heat generated by an orthopaedic drill or burr has been found to be positively correlated with the extent of thermal damage done to bone [15].Study done by Res and Roe et al on bovine femora showed that without irrigation, sawing and burring bone generate temperatures which were high enough to cause irreversible histological changes to bone, including cell death. Bones were burred with a Navio PFSTM handheld robotic device (Blue Belt Technologies Inc.), which was connected to an Ansbach console. Identical spherical burrs of 6mm diameter were used throughout the duration of this study [15] .They concluded although the temperatures were high enough to cause osteonecrosis and this temperature can be reduced by applying a cooling agent to the cut surface, so it is advised that cooled saline should be used in orthopaedic procedures such as TKA while burring and sawing the bone. If irrigation is unavailable, intermittent bone cutting is suggested, to prevent onset of osteonecrosis.

So far to the best of our knowledge no in-vitro study had been done to prove whether this thermal osteonecrosis by burr leads to early aseptic component loosening. So, our study had proved that all burr robotic assisted TKA does not causes early loosening or failure due to thermal osteonecrosis if proper cooling system is used. Limitation of our study is small sample size, short term follow up and also it’s not correlated with clinical outcome.

Conclusion:

Our study had proved that all burr robotic assisted TKA does not causes early aseptic loosening or failure due to thermal osteonecrosis.

On behalf of all authors, the corresponding author states that there is no conflict of interest.

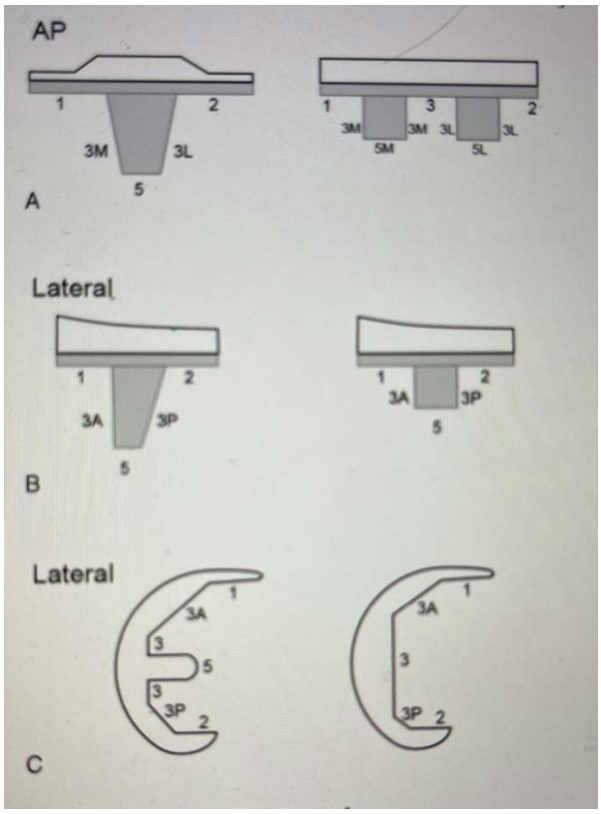

Figure and Table Legends

Figure 1 . (A) Coronal and (B) sagittal radiographic schematic of keeled and two-peg implants with zones for documentation of radiolucent lines and osteolysis. (C) Sagittal plane radiographic schematic of femoral implant with zones denoted for documentation radiolucent lines and osteolysis.• Zone 1: medial baseplate• Zone 2: lateral baseplate• Zone 3: central keel/stem region ("M" and "L" designate the respective regions of the central keel)• Zone 4: Revision TKA Stem Extension ("M" and "L" designate the respective regions of the stem extension) • Zone 5: inferior aspect of tibial keel/stem Tibial Component Lateral View: Zone 1: anterior baseplate Zone 2: posterior baseplate Zone 3: central keel/stem/peg fixation region ("A" and "P" designate the respective regions of the central keel) Zone 4: Revision TKA Stem Extension ("A" and "P" designate the respective regions of the stem extension) Zone 5: inferior aspect of tibial keel/stem Femoral Component Lateral Zone 1: anterior flange Zone 2: posterior flange Zone3: central box/peg/distal fixation region("A" and "P" designate the respective chamfers if visible) Zone 4: Revision TKA Stem Extension ("M" and "L" designate the respective regions of the stem extension on the AP view "A" and "P" designate the respective regions of the stem extension on the lateral view.(Figure courtesy from Meneghini Modern Knee Society Radiographic Evaluation System[9])

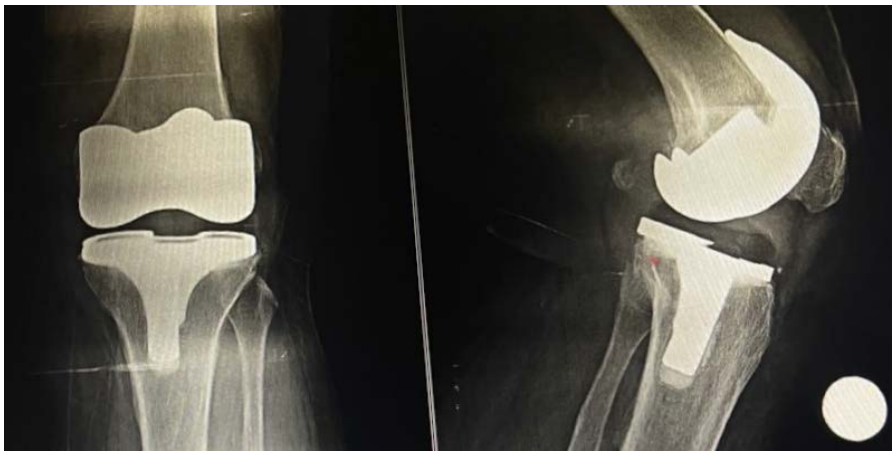

Fig 2 : 24 months post-operative Anterio-posterior and Lateral knee radiographs of one patient not showing any radiolucent lines.

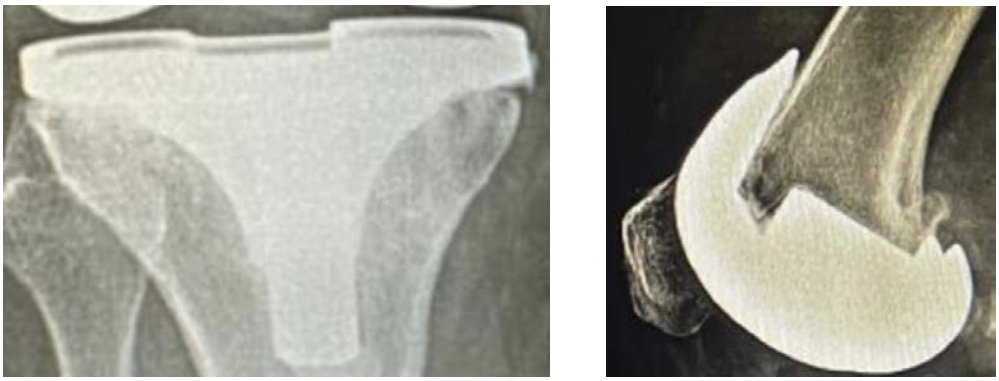

Fig 3 : 28 months post-operative Anterio-posterior radiograph showing ARL in tibia (zone 1) and Lateral knee radiographs showing ARL in femur (zone 3a) in two different patient

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