Preservation of subchondral sclerosis as the platform for tibial component support in total knee arthroplasty

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Background
In the present study, we hypothesize that preservation of adequate surface area of the subchondral sclerotic bone on the proximal tibial cut surface would provide a stronger foundation for tibial component support. This would minimize or eliminate the potential for component subsidence or loosening when minor degrees of misalignment are encountered, added to the potential advantage of avoiding complex reconstruction in osteoarthritic varus knees with excessive medial wear. The purpose of this study was to investigate the midterm outcome of total knee arthroplasty upon seating the tibial component partially on the medial sclerotic subchondral bone in varus osteoarthritic knees.

Patients and methods
Proximal tibial resection was kept to a minimum in 54 consecutive primary total knee arthroplasties. The remaining sclerotic surface area on the medial tibial plateau cut surface was freshened with a saw blade, and multiple anchorage holes were made for cement interdigitation. Patients were followed up for a mean period of 38.4 months both clinically and radiologically according to the knee society scoring system.

Results
At the last follow-up, the average clinical knee society score (KSS) was 88.4 (range from 72 to 94) compared with an average preoperative KSS of 32.5. The average knee function score at the last follow-up was 86.3 (range from 68 to 93) compared with the average preoperative functional score of 31.7. The coronal tibial component β angle was within $\pm 3^{\circ}$ of neutral alignment in 94% (51) of patients. The mean β angle was $89.6 \pm 2.8^{\circ}$, with a mean varus deviation of 0.4° from the neutral angle. At the latest follow-up, there was no was no evidence of component loosening or subsidence in any of the cases in this study.

Conclusion
In conclusion, the proposed surgical approach has proven beneficial to midterm durability and survival of the total knee implant on both clinical and radiographic basis. Avoidance of complex reconstruction is another potential advantage of adopting this technique in osteoarthritic varus knees with excessive medial wear. Further long-term follow-up studies are required to document the long-term durability.

Keywords:
platform for tibial, sclerosis, subchondral, total knee arthroplasty

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Introduction

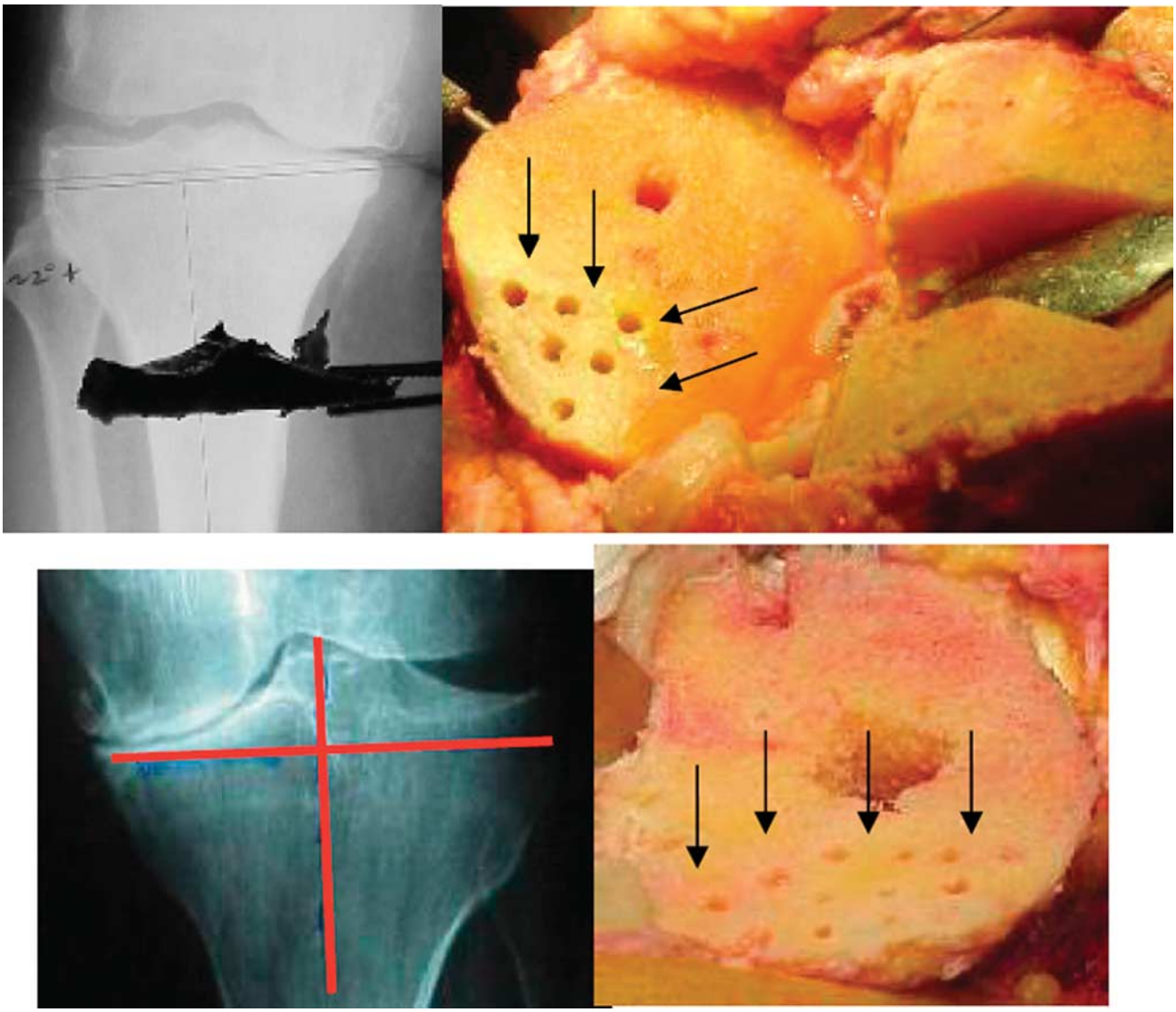
The strength of the tibial juxta-articular cancellous bone rapidly decreases distal to the subchondral plate. With the absence of the subchondral plate, which distributes the load to the cortex, increased loads are sustained by the cancellous bone. Maintenance of a strong tibial cancellous bone is necessary to prevent overload of the proximal tibial bone after reconstruction of the knee by arthroplasty [1].

Bone strength correlates with malalignment, being stronger on the side of the deformity. The medial compartment in knees with varus deformity was 50% stiffer compared with the lateral compartment of normal knees. There was a significant reduction in bone strength with increasing depth of bone resection from the articular surface. Therefore, a prosthesis that requires limited tibial bone resection and covers the entire cut surface of the tibia would provide fixation in the strongest bone [2].

Dorr *et al.* [3] recommended tibial bone resection be limited to 1 cm distal to the lateral subchondral plate or 5 mm distal to the medial subchondral plate in varus osteoarthritic knees. However, there is no universal agreement to an exact level of proximal tibial resection. This is because the magnitude of forces acting on a single tibial plateau on the concave side of the angular deformity would vary according to the degree of deformity; therefore, the amount of bony erosions and

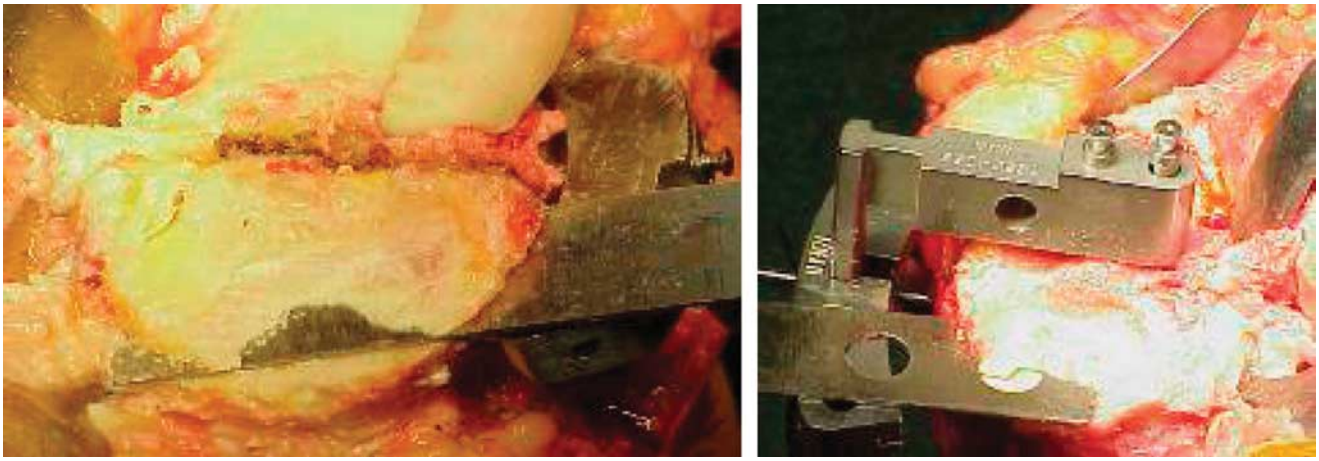
Study conducted at Department of Orthopaedic Surgery, Ain Shams University Hospital, Ain Shams University, Cairo, Egypt.

Figure 1



Left: proximal tibial resection planned to exit medially at the level of the sclerotic subchondral bone, being perpendicular to the anatomical axis. Right: the proximal tibial cut surface, note the sclerotic bony surface area on the medial plateau (arrows).

Figure 2



Exit of the saw blade on the medial side of the tibial cut.

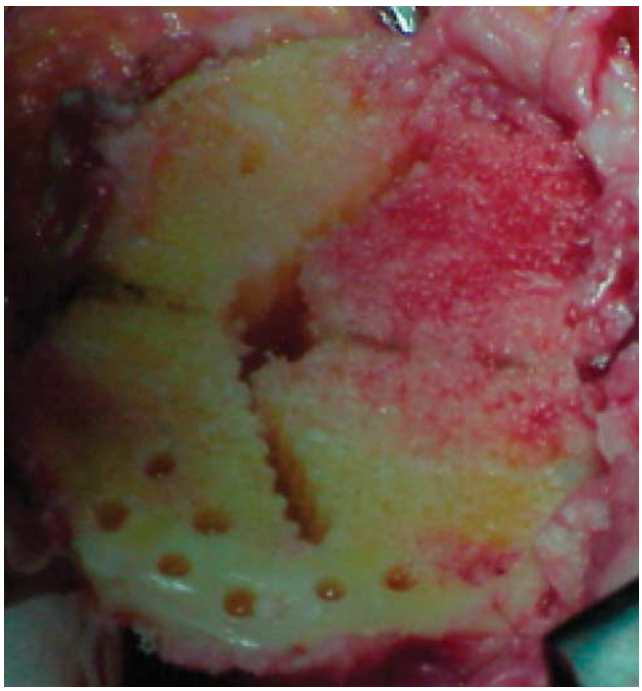
wear of the proximal tibia is one variable that requires special consideration during planning of proximal tibial resection.

In the present study, we hypothesize that preservation of adequate surface area of the subchondral sclerotic bone on the proximal tibial cut surface would provide a stronger foundation for tibial component support. This would minimize or eliminate the potential for component subsidence or loosening when minor degrees of misalignment are encountered. In addition, avoidance of complex reconstruction is another potential advantage of adopting this technique in osteoarthritic varus knees with excessive medial wear.

Patients and methods

This study investigated 54 consecutive primary total knee replacements performed in Ain Shams University Hospital, Egypt, between May 2006 and August 2008. All patients were candidates for total knee replacement surgery with the main aetiology being varus osteoarthritis in all cases. In this series, there were 30 women and 21 men with a mean age of 64.3 ± 5.8 years. A total of 48 patients underwent unilateral primary knee replacement and three patients underwent simultaneous bilateral primary knee replacement surgery. The mean angle for preoperative varus deformity was 14.2 ± 5.1°. All patients underwent knee replacement with a fixed bearing, cruciate substituting implant design [Zimmer NexGen system (USA) was used in 62% of cases, Depuy PFC Sigma system (USA) in 36% and Scorpio system (USA) in 2%]. The knee society scoring system was used for follow-up evaluation both clinically and radiologically at regular postoperative intervals of 3 months, 6 months and 1 year and yearly thereafter. Special attention was given to the evolution and progression of radiolucent lines beneath the tibial tray and the coronal alignment angle of the tibial component.

Figure 3



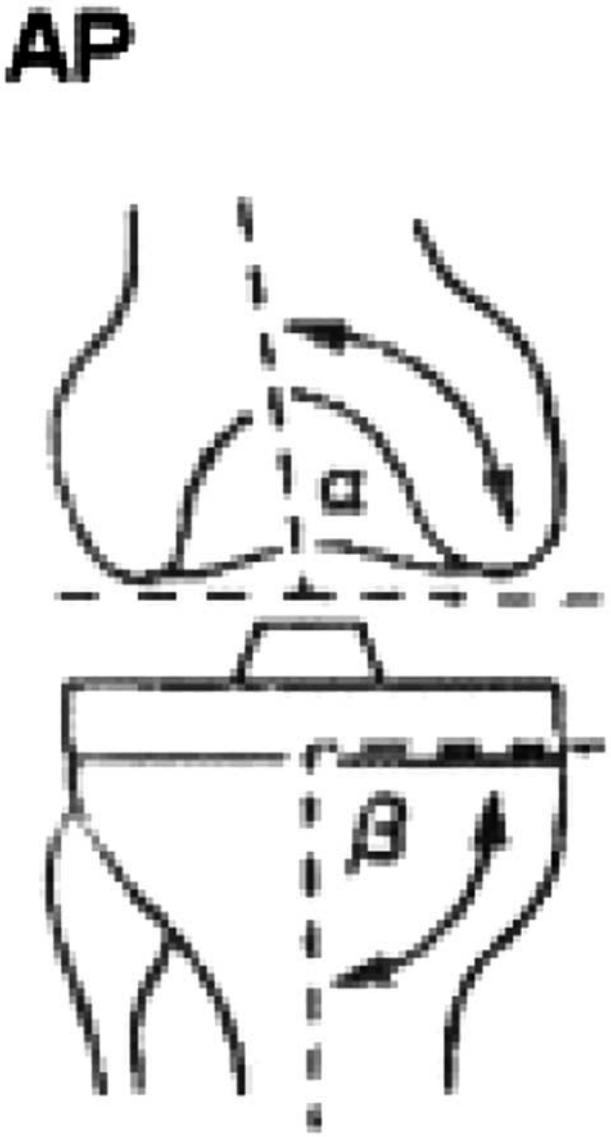
The prepared tibial cut surface after freshening of sclerotic medial subchondral bone and drilling of multiple anchorage holes.

Surgical technique

The proximal tibial resection level was planned on the basis of preoperative radiographs, being drawn perpendicular to the anatomical axis of the tibia such that the medial end of the resection plane exits immediately above the medial subchondral plate (Fig. 1).

The proximal tibial cutting jig was adjusted so as to match the planned resection level using a reference resection guide applied in the medial slot of the cutting jig, with its distal end encasing the highest level of the medial subchondral plate.

Figure 4



Radiographic angles for assessment of coronal component position [4].

The proximal tibial cut was considered satisfactory when the cutting saw blade was seen to exit medially just above the sclerotic subchondral bone (Fig. 2).

The remaining medial sclerotic bone was freshened by a saw blade, and then multiple 2 mm drill holes were made to a depth of 2–3 mm to ensure cement anchorage in the sclerotic subchondral bone (Fig. 3).

Postoperative radiographic assessment

Coronal tibial component position

The coronal inclination of the tibial component was estimated on the anteroposterior view by measuring the β angle, the angle between the anatomical axis of the tibia and a line tangential to the tibial tray. Progressive deviation from neutral alignment (90°) was estimated from postoperative and follow-up radiographs [3] (Fig. 4).

Radiolucent lines

On the AP view of the tibia, seven zones can be delineated. An example of a tibial plateau interface fixation zonal assignment system is shown in Fig. 5. The scoring system was determined by measuring the width of the radiolucent lines for each zone in millimetres. The total widths were added for each zone. The total numerical score produced can be rated as follows for a seven-zone tibial component: a value of 4 or less and nonprogressive is probably not significant; 5–9 should be closely followed for progression and 10 or greater signifies possible or impending failure, regardless of symptoms [4].

Results

Patients were followed up for a mean period of 38.4 months (range 26–48 months). At the last follow-up, the average clinical knee society score (KSS) was 88.4 (range 72–94) compared with an average preoperative KSS of 32.5 (range 16–51). The average knee function score at the last follow-up was 86.3 (range 68–93) compared with an average preoperative functional score of 31.7 (range 17–49). At the latest follow-up, the mean postoperative range of motion was 119.6 ± 9.3° compared with a mean preoperative range of 92.4 ± 7.1°.

Component position

The coronal tibial component β angle was within ± 3° of neutral alignment in 94% (51) of patients. The mean β angle was 89.6 ± 2.8, with a mean varus deviation of 0.4° from the neutral angle. At the latest follow-up, none of the 54 cases had angular subsidence of the tibial component, including the three outliers beyond the safe range of deviation from neutral alignment (± 3° from 90°).

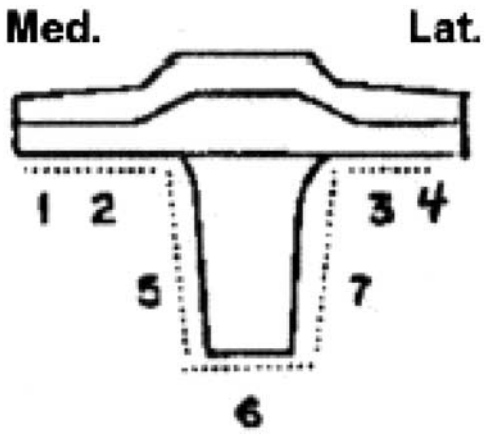
Radiolucent lines

Radiolucent lines beneath the tibial component appeared in zones 1 and 2 in four cases, in zones 3 and 4 in two cases and in zone 5 in 1 case. All radiolucent lines were nonprogressive, within a thickness of 1 mm (Fig. 6). At the latest follow-up, none of the 54 cases scored more than 2 on the radiolucent line assessment scale, which is considered as nonsignificant.

Discussion

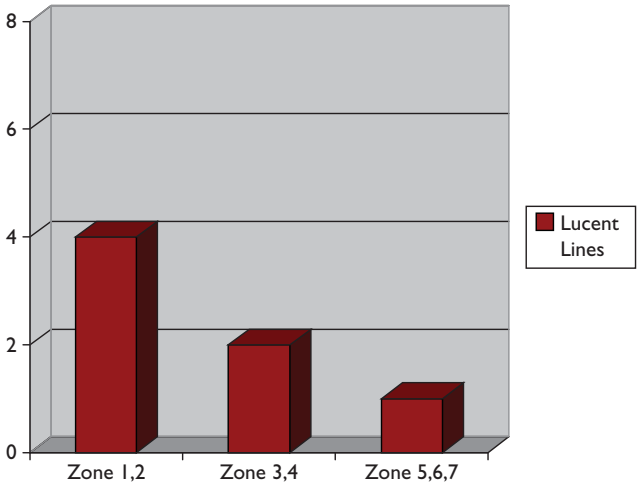
An understanding of the anatomy of the proximal tibia is critical to the concepts of tibial implant fixation. The proximal tibia consists of a dense subchondral bone plate with a thin cortical rim. Beneath the subchondral plate lies cancellous bone. The density of the cancellous bone is greatest on the side of the deformity (medial in a varus knee), according to Wolff's law. The cortical rim remains quite thin at the level of resection typically performed for total knee arthroplasty. The shape of the proximal tibia is not symmetrical, with the medial condyle being larger compared with the lateral condyle. The stiffest bones are the central and medial parts of the medial tibial plateau and the posterolateral aspect of the lateral tibial plateau. Cortical bone areas at the level of osteotomy for a total

Figure 5



Suggested guidelines for assignment of zones: 1 and 2 for the medial plateau, 3 and 4 for the lateral plateau and 5–7 for stem fixation. If there are no stems, the central part of the tibial plateau should be assigned to zones 5–7 [4].

Figure 6



Radiolucent lines.

knee comprised less than 1% of the total cross-sectioned area [2].

The present study postulates a conservative approach for the amount of bone resection from the proximal tibia in varus osteoarthritic knees undergoing total knee arthroplasty. Benefits of adopting this conservative approach in osteoarthritic varus knees with excessive medial wear include: (a) seating the tibial component on a mechanically stronger bone (b) tibial component subsidence or minimization or avoidance of loosening, (c) upsizing the tibial component, distributing the load to a larger surface area (better contact stresses and load distribution), (d) preservation of the major surface area for collateral soft tissue attachments, (e) preservation of bone stock for future revision surgery and (f) avoidance of complex reconstruction.

The same point of view was emphasized by several authors in the orthopaedic literature. Rand [5] investigated the mechanical strength of the proximal tibia and found that the mechanical strength of the tibial bone decreases with increasing depth of resection. At a depth of 35 mm from the tibial plateau surface, the bone was only one-third as strong as it was at a 5 mm depth of resection. Therefore, he concluded that bone resection should be minimized and bone defects should be filled rather than resecting additional bone in most cases.

Ollivierre and Malek [6] reported that lowering the tibial resection line is mechanically unsound and may result in less than optimal support for the prosthesis. In addition, with more distal cuts, there is danger of compromise of important ligamentous attachments. Sculco [7], in his study, warned that, with distal resections, sizing problems may occur because of the diminished cross-sectional area as one progresses down the tibia distally; besides, the tibial component becomes seated on the poor-quality cancellous bone.

On the basis of these data, it appears that reconstitution of bone defects is preferable to additional resection of bone. Therefore, the temptation to resect more bone should be resisted. The cancellous bone is much weaker as we move further away from the native articular surface [8].

One concern was about the quality of cemented fixation to the sclerotic bone compared with cement interdigitation with the cancellous surface beneath. In the present study, the remaining sclerotic surface area was routinely freshened with a saw blade and multiple anchorage holes were made for cement interdigitation. At the latest follow-up, there was no evidence of component loosening or subsidence in any of the cases in this study.

Conclusion

The proposed surgical approach has proven beneficial to midterm durability and survival of the total knee implants both on clinical and radiographic basis. Avoidance of complex reconstruction is another potential advantage of adopting this technique in osteoarthritic varus knees with excessive medial wear. Further long-term follow-up studies are required to document the long-term durability.

Acknowledgements

Conflicts of interest
There are no conflicts of interest.

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