

Teknik Rekonstruksi Menggunakan Kombinasi Hemiarthroplasty dengan Plate dan Screw pada Defek Tulang Proximal Femur pasca Tindakan Reseksi Tumor Tulang: Studi Luaran Fungsional dan Finite Element Analysis = Reconstruction Technique Using a Combination of Hemiarthroplasty with Plate and Screw for Proximal Femur Bone Defects Following Bone Tumor Resection: A Study on Functional Outcomes and Finite Element Analysis

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Abstrak

Latar Belakang: Metastatic Bone Disease (MBD) pada femur proksimal menyebabkan fraktur patologis yang mengganggu kualitas hidup. Reseksi tumor meninggalkan defek tulang masif, mengganggu stabilitas biomekanik. Bipolar hemiarthroplasty (BHA) adalah alternatif hemat biaya dibandingkan megaprotesis, namun tanpa fiksasi pelat, luaran fungsional sering suboptimal. Luaran fungsional dinilai melalui skor Musculoskeletal Tumor Society (MSTS) untuk nyeri dan fungsi ekstremitas serta Short Form-36 (SF-36) untuk kualitas hidup fisik dan mental. Finite Element Analysis (FEA) memodelkan distribusi tegangan, deformasi, dan ketahanan implan, memberikan wawasan biomekanik presisi. Penelitian ini mengevaluasi luaran fungsional dan biomekanik BHA dengan dan tanpa fiksasi pelat pada tumor femur proksimal.

Metode: Penelitian serial kasus dan komparatif analitik dilakukan di RSUPN Dr. Cipto Mangunkusumo (2015–2024). Luaran fungsional 11 pasien dinilai menggunakan skor MSTS dan SF-36 melalui rekam medis dan wawancara. Uji biomekanik pada sawbone dengan FEA menggunakan ANSYS 2020 memodelkan defek tulang (0, 5, 10, 15 cm) dan membandingkan BHA dengan dan tanpa locking compression plate (LCP) pada beban fisiologis (735–8800 N).

Hasil: BHA dengan LCP meningkatkan fungsi fisik dan kesehatan mental (SF-36), sedangkan BHA tanpa LCP unggul dalam pengendalian nyeri (MSTS). Biomekanik menunjukkan BHA dengan LCP memiliki distribusi tegangan yang merata, total deformasi, dan fatigue life lebih lama pada reseksi 0–5 cm, namun menurun pada 10 cm dan sangat rentan pada 15 cm dengan peningkatan risiko kegagalan mekanis

Kesimpulan: BHA dengan LCP meningkatkan fungsi fisik dan kesehatan mental (SF-36), sedangkan BHA tanpa LCP lebih efektif untuk nyeri (MSTS). Untuk defek 5 cm, BHA dengan LCP direkomendasikan karena stabilitas biomekanik dan fungsi fisik superior. Pada defek 10 cm, LCP digunakan karena diambang kapasitas beban. Untuk defek 15 cm, fiksasi tambahan karena risiko besar terhadap kegagalan struktural

.....Background: Metastatic Bone Disease (MBD) in the proximal femur causes pathological fractures that impair quality of life. Tumor resection results in massive bone defects, disrupting biomechanical stability. Bipolar hemiarthroplasty (BHA) is a cost-effective alternative to megaprosthesis, but functional outcomes are often suboptimal without plate fixation. Functional outcomes are assessed using the Musculoskeletal Tumor Society (MSTS) score for pain and limb function and the Short Form-36 (SF-36) for physical and mental quality of life. Finite Element Analysis (FEA) models stress distribution, deformation, and implant

durability, providing precise biomechanical insights. This study evaluates the functional and biomechanical outcomes of BHA with and without plate fixation in proximal femur tumors.

Methods: A case series and comparative analytical study was conducted at RSUPN Dr. Cipto Mangunkusumo (2015–2024). Functional outcomes of 11 patients were assessed using MSTS and SF-36 scores via medical records and interviews. Biomechanical testing on sawbone with FEA using ANSYS 2020 modeled bone defects (0, 5, 10, 15 cm) and compared BHA with and without locking compression plate (LCP) under physiological loads (735–8800 N).

Results: BHA with LCP enhanced physical function and mental health (SF-36), while BHA without LCP was superior in pain control (MSTS). Biomechanically, BHA with LCP showed uniform stress distribution, controlled deformation, and longer fatigue life at 0–5 cm resection, but performance declined at 10 cm and was highly vulnerable at 15 cm with increased mechanical susceptibility.

Conclusion: BHA with LCP improves physical function and mental health (SF-36), while BHA without LCP is more effective for pain relief (MSTS). For 5 cm defects, BHA with LCP is recommended for superior biomechanical stability and physical function. At 10 cm, LCP is necessary despite nearing structural capacity limits. For 15 cm defects, additional fixation is mandatory due to high mechanical susceptibility.