Finite Element Analysis of the Mechanical Performance of Nitinol Biliary stent: Effect of Material Properties

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Stent implantation is counted as a major strategy to solve gastrointestinal diseases such as biliary obstruction in the previous decade. In recent times, owing to problems such as restenosis after stent implantation, the ability to low stent twist, unsuitable dynamic behavior and inadequate strength radial mechanical of stent, utilization of Nitinol superelastic stents to minimize the above problems is considered. In the present article, effects of material properties on mechanical performance of z-shaped Nitinol wire stent under crushing test for clinical applications are studied by finite element modeling. Nitinol stent with applying 90 % crushing, less chronic outward force, high radial resistive strength ,appropriate superelastic behavior and A_f temperature of 24°C, have better mechanical and clinical performance.

Keywords: stent, Biliary duct, Nitinol, finite element analysis, mechanical performance

1. INTRODUCTION

A main cause of death around the world is gastrointestinal disease [1]. Biliary obstruction is the most famous gastrointestinal ailment [2]. Stenting placement has been used as a major solution to this hitch during past decade [3-6]. Employ of stent has two chief objectives: (1) preventing short term effects of intimal dissection and elastic recoil and (2) preventing long effects such as restenosis due to the neointimal hyperplasia. Successful use of stent is bound to the following conditions: (a) good controllability to achieve an adequate fixation to the duct wall;(b) satisfactory resistance against the elastic recoil; (c) resistance to fatigue owing to the pulsatile flow on body kinematics; (d) size minimization of the device for easier percutaneous procedure; (e) low thrombogenicity; (f) high biocompatibility and (g) long-term palliation of patients from malignant obstructive jaundice. Previous reports show that stent placement results in palliation of malignant obstructive jaundice and improves the quality of living of the patient [4].Application of Nitinol as a functional Biliary endoprosthesis is due to its long patency results[3].Parameters affecting stent performance of Nitinol are superelasticity, mechanical hysteresis, chronic outward force (COF), radial resistive force (RRF),stress distribution, plateau stress, strain distribution and martensite percentage [5-8].Desirable Nitinol stents require lowest COF, highest RRF, wide stress plateau ,full hysteresis loop, small localized stress concentrations and large deformation superelastic strains[5-12].Long fatigue life and safe failure domains are also needed [6,13-15].For geometric design of the stent, several parameters exist which describe mechanical properties of the stent [6, 16-17].These parameters are: stent length, stent inner diameter, stent chord diameter, stent turning number, segments angle and stent radial contraction.

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