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Development of composite bioresorbable stents: Computational and experimental investigation

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Stents are vital devices to treat vascular stenosis in pediatric patients with congenital heart disease. Bioresorbable stents (BRSs) have been applied to reduce challenging complications caused by permanent metal stents. However, it remains almost a total lack of BRSs with satisfied compression performance specifically for children with congenital heart disease, leading to importantly suboptimal effects. In this work, Composite bioresorbable stents with poly(p-dioxanone) (PPDO) monofilaments and poly(p-dioxanone)/polycaprolactone (PPDO/PCL) composite braided yarns (cBYs) were fabricated on a 32 bobbin braiding machine 1(a)) with different feed yarn ratios (7:1 for cBRS type A, 3:1 for cBRS type B, and 32:0 for PPDO prototype). Then they were thermally treated in air at 90 □ for an hour to stabilize the structure and soften the cBYs to composite melted yarns (cMYs). The compression properties of cBRSs were evaluated using a parallel compression tester.The stent stress distribution and deformation mechanism were also analyzed by finite element analysis Two restriction force, the friction force between yarns, and the peeling force (PF) among bonded cMYs existed in the cBRSs. The friction resistances were all less than 100 mN in the prototypes. However, the peeling force (PF) of the bonded yarns was as high as 2126.67 ± 133.14 mN, which restricted yarn movement greatly. The compression force was promoted dramatically for the novel composite prototype stents by 124.06 % in cBRS-A and 169.58 % in cBRS-B prototype, compared with that in the control (572.60 ± 27.98 mN/cm). Stability of the composite self-expanding prototypes to resist deformation was also higher than that in the control prototype. Specifically, the values were 89.89 ± 1.76 %, 93.09 ± 1.78 % and 94.05 ± 1.60 % for the control group, cBRS type A, and cBRS type B, respectively. Higher stresses existed in cMYs for cBRSs. And with the increase of bonding points, stress difference between cMYs and PPDO increased, as shown in cBRS type B. Moreover, bonded yarns bent greatly and braiding angles kept unaltered in cBRSs, resulted in higher Von Mises stress concentrated near the bonding points compared with PPDO prototype.Hence, the cBRSs mechanically reinforced skeletons were formed by the connected and bonded cMYs, and the stability to resist external load increased with the number of composite yarns. The results of this study may inspire future development of bioresorbable polymeric stents and open new prospects for the use of composite design in medical devices.

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