# SpiralAT: First Generation Artificial Trachea

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## Mission Statement

**We aim to provide the first artificial trachea unit that is ready for immediate implantation through a single-step surgical procedure.**

## Motivation for SpiralAT

***Clinical Significance of Tracheal Replacement***

- 90% of primary tracheal cancers are malignant.
- Of the 90,000 new cases/year of cancers in nearby throat tissues, 25-50% will develop into secondary tracheal cancer.
- Other patients suffer from congenital defects and physical trauma.

***Current Approaches Sub-optimal***

- Tracheal resection is limited because reconstruction after resection is not feasible.
- Radiation is not fully reliable because studies show inconsistent outcomes in effectiveness.
- Case-by-case artificial tracheas have been built, but require multi-staged surgeries that are impractical for patients with urgent needs.

**There is no standardized solution.**

## Design Concept

***Design Objectives***

| | |
|---|---|
| Dimensions | 3.3-3.5 cm diameter<br>6 cm length |
| Functional Range of Motion | Flexibility in flexion/extension (flex/ext) and lateral bending |
| Biocompatibility | Scar tissue < 10% of total surface area |
| Stable and Sufficient Vascularization | > 90% of tissue vascularized |

***Design Components***

- Synthetic materials allow immediate use.
- Helical geometry provides stability and flexibility.
- Exterior casing promotes tissue integration.

## Solution: The SpiralAT

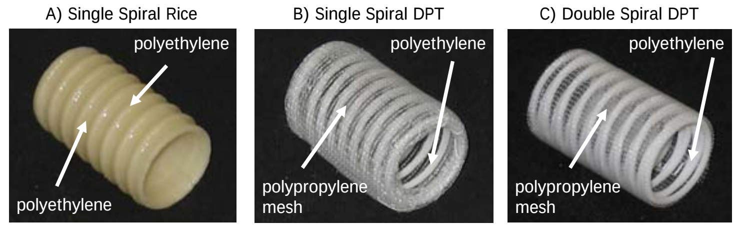


Fig. 1. The three versions of the SpiralAT have different structures and are made of different materials. Each version consists of 2 components, a helical support structure and a shell.

## Mechanical Testing

***3-point bending test***

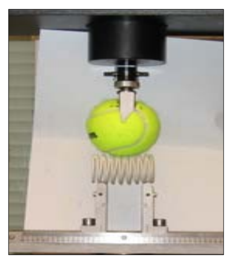

Fig. 2. Simulation of flex/ext using a tennis ball covered crosshead to distribute the force across a wide area of the sample

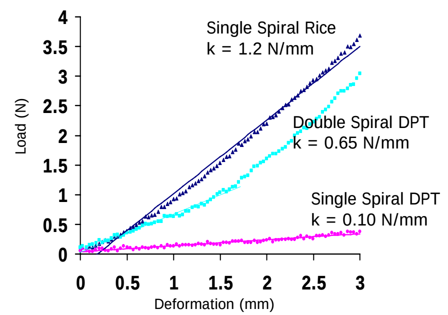


Fig. 3. Single Spiral Rice was the stiffest, followed by Double Spiral DPT and Single Spiral DPT. Adding an additional helix to the Single Spiral DPT increased stiffness. (crosshead speed=20 mm/min, max extension=10 mm)

***Compression test***

Fig. 4. Simulation of flex/ext lateral bending using an angled wedge attached to upper crosshead used to focus compressive force on one side

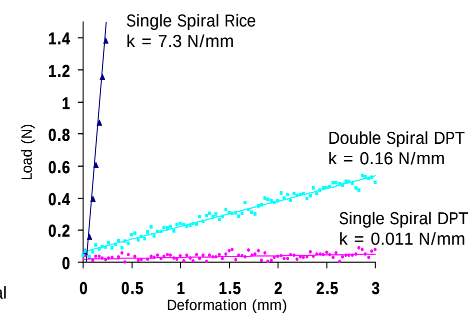


Fig. 5. Increasing load resulted in elastic deformation. Double Spiral DPT was stiffer than Single Spiral DPT. (crosshead speed=20 mm/min, max extension=10 mm)

## Future Work

***Biocompatibility Studies in Canines***

- Quantitative analysis of skin flap integration by measuring cross-sectional area at the most stenotic point.
- Qualitative endoscopy of tissue ingrowth and dehiscence.

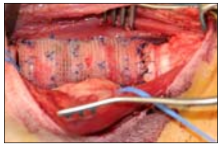

Fig. 6. Post-operative examination of an artificial trachea in canine throat

## Conclusion

- **Need:** Readily implantable, tracheal replacement performed in a single-step surgery.
- **Solution:** Standardized artificial trachea unit that comprises a polyethylene double-helical structure for stability and a polypropylene mesh for good tissue integration. **The Double Spiral DPT is the most promising.**
- **Testing:** The SpiralAT allows for flexible motion without any permanent deformation or fracture.

## Acknowledgements

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