

Endoscopic Dynamic Optical Contrast Imaging Detects Chronic Vocal Fold Scar in a Rabbit Corpectomy Model

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Abstract

Introduction: Accurate, noninvasive detection of vocal fold (VF) scarring remains a clinical challenge. We evaluated endoscopic Dynamic Optical Contrast Imaging (DOCI) in a rabbit model of unilateral VF corpectomy.

Methods: Eight rabbits underwent baseline endoscopic DOCI of both VF followed by unilateral corpectomy; The uninjured side served as controls. Serial in vivo endoscopic DOCI was performed at approximately 2, 4, and 8 weeks. At the terminal time point, larynges were imaged endoscopically in situ and VF tissue was excised for ex vivo DOCI and pentachrome histology. Scarred and contralateral normal VF were compared within the same image, with the rabbit as the unit of analysis.

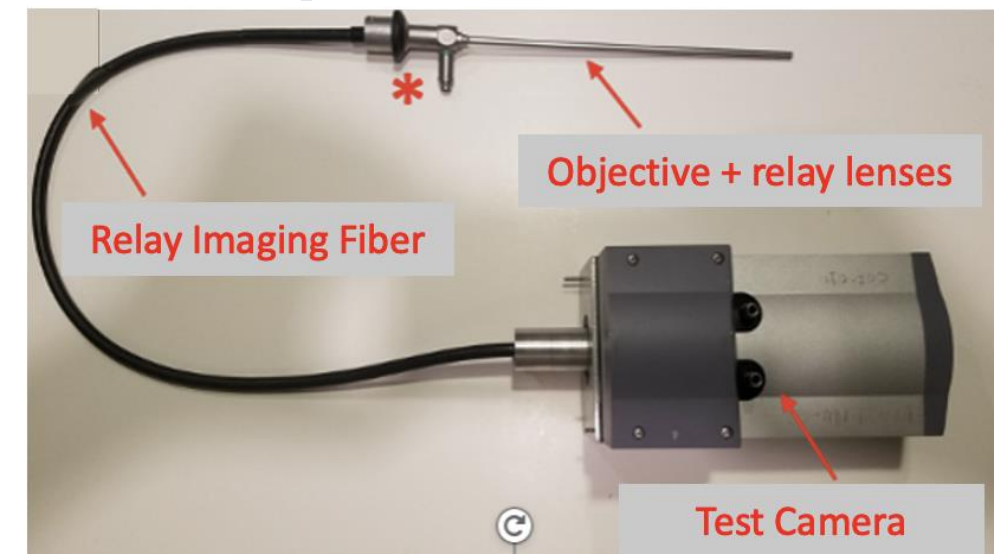
Results: No difference between sides was present at baseline ($\Delta = -0.021$, $n = 3$). By 8 weeks, the scarred VF showed higher DOCI values than the contralateral normal VF in all 7 evaluable rabbits in the Ch1 band 365nm LPF channel (mean $\Delta = 0.048$, 95% CI 0.017–0.078, $p = 0.008$), a finding that persisted when only in vivo images were analyzed. Differences at 2 and 4 weeks were directionally similar but variable. Ex vivo spectrally resolved DOCI showed a small, non-significant difference in the same direction.

Conclusions: Endoscopic DOCI detected a consistent side-to-side difference in chronically scarred VF, supporting its feasibility as a noninvasive, label-free tool for VF scar assessment. Standardized acquisition settings and improved endoscopic light delivery are needed before diagnostic accuracy can be established.

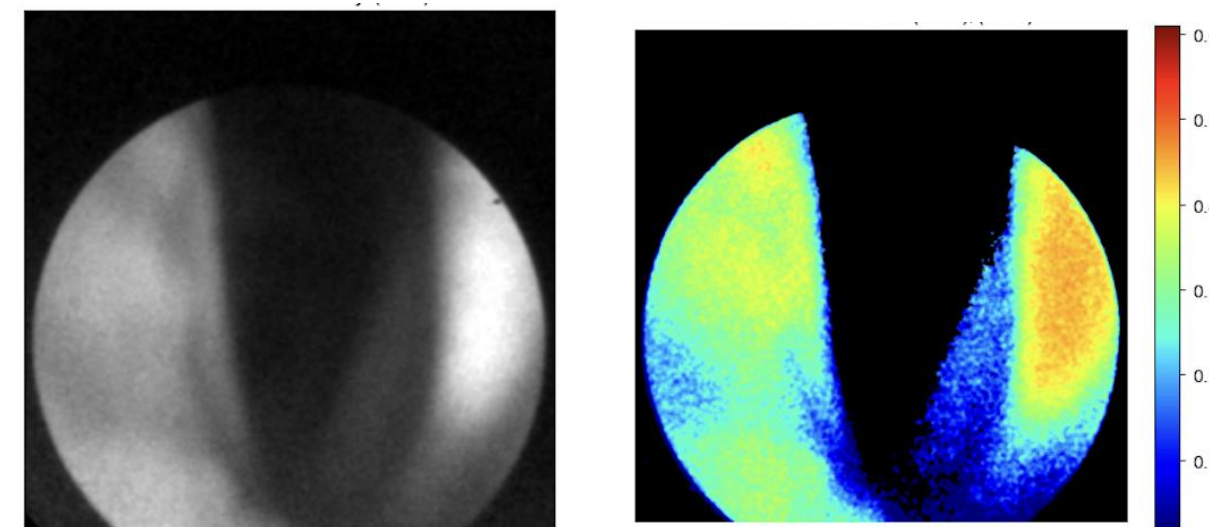
Study Workflow

- 0 Baseline:** bilateral DOCI → unilateral corpectomy
- 2 Week 2:** in vivo endoscopic DOCI
- 4 Week 4:** in vivo endoscopic DOCI
- 8 Week 8:** in vivo + in situ endoscopic DOCI
- Ex Terminal:** ex vivo DOCI → pentachrome histology

Endoscopic DOCI



Wide-field gated imaging of the laryngeal surface through a rigid endoscope. Each pixel encodes the ratio of decay to total fluorescence (lifetime-weighted DOCI value). **Channel 1 = [405 LPF nm]**; channels 3 and 5 analyzed where available.



Grayscale vs DOCI Image of VF, comparing scar side vs Normal after 8 weeks. Red is longer lifetime value i.e. scar, vs blue lower lifetime value

Paired analysis

- ROIs on scarred and contralateral normal VF drawn in the same frame, so gain, gate and offset cancel.
- $\Delta = \text{Scar} - \text{Normal}$ per image and channel.
- Δ averaged per rabbit per week (rabbit = unit of analysis).
- One-sample t-test of Δ vs 0, two-tailed; exploratory.

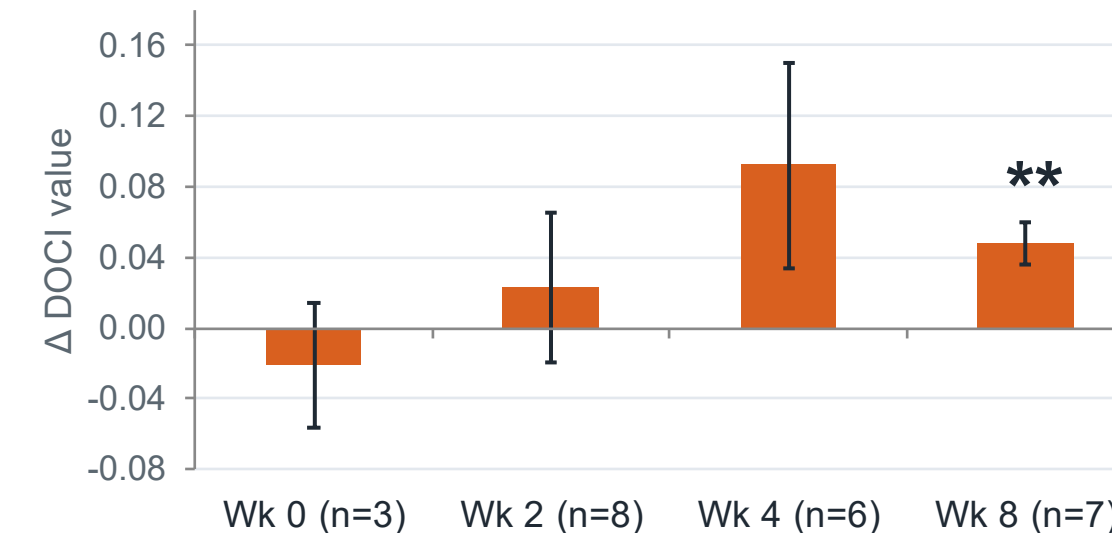
In Vivo Endoscopic Results

7 / 8

rabbits showed a higher DOCI value in the scarred VF than in the contralateral normal VF at 8 weeks

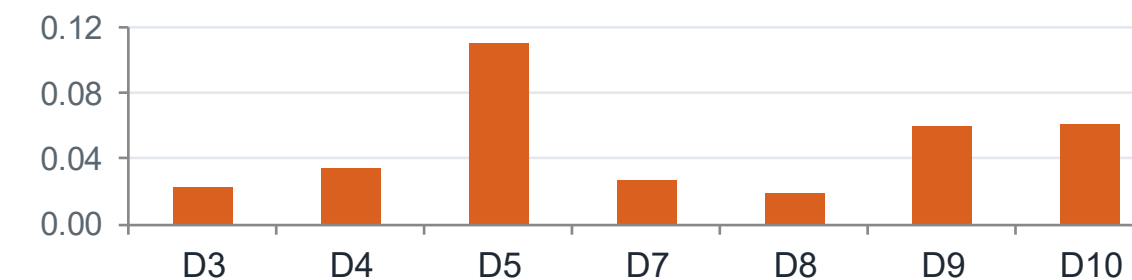
$\Delta = +0.048$ (95% CI 0.017–0.078), $d_z = 1.46$, $p = 0.008$

Ch1 Δ (Scar – Normal) by week, mean $\pm$ SEM



** $p < 0.01$ vs 0 (one-sample t-test, rabbit = unit). Change across weeks was not significant (week 8 vs 0, $p = 0.19$).

Week 8: Δ in each rabbit



Why are weeks 2 and 4 more variable?

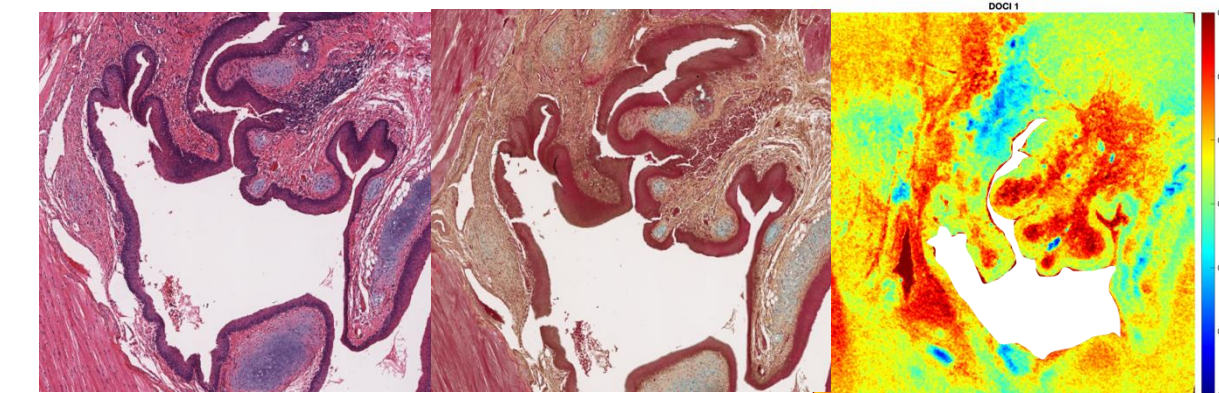
Image quality: 40% of week-2 image pairs were low-signal or blurry (0% at weeks 4 and 8).

Acquisition: 40% of week-2 pairs used a 30 ns gate (all 40 ns from week 4); normal-VF signal 0.35 ± 0.22 vs 0.53 ± 0.12 at week 8.

Sampling: 1.3 paired images per rabbit at week 2 vs 2.4 at week 8.

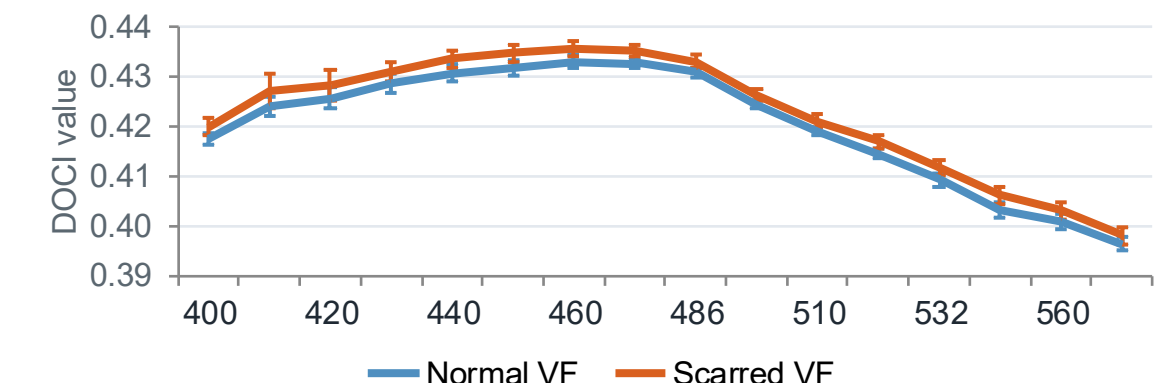
Biology: weeks 2–4 span active healing (edema, granulation, new collagen), so the lesion is heterogeneous; image-to-image SD within rabbits peaked at week 4.

Ex Vivo DOCI & Histology

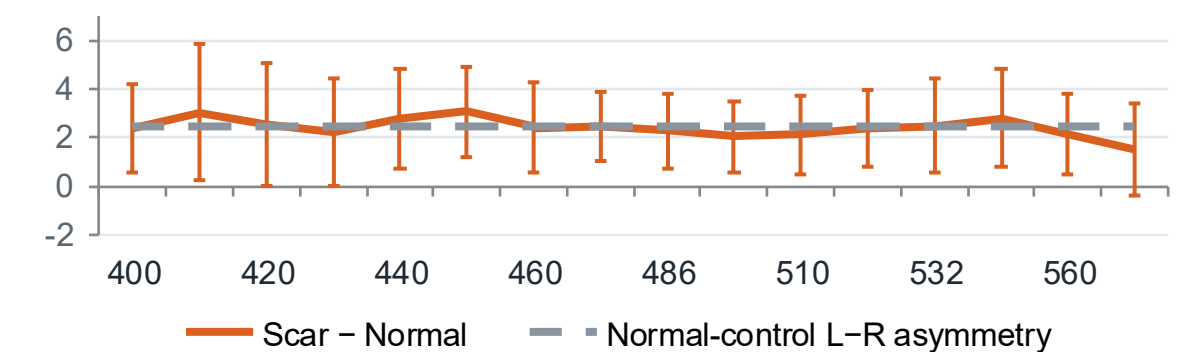


H&E Stain Pentachrome Stain DOCI image
Red regions in the DOCI image correspond with Scar

Ex vivo spectra, mean $\pm$ SEM ($n = 8$)



Scar – Normal, mean $\pm$ SEM ($\times 10^{-3}$)



Spectra nearly overlap. The difference (n.s., $p \geq 0.13$) matches the left–right asymmetry of bilateral-normal controls (dashed) and is driven by 2 rabbits (D3, D8) with channel-flat offsets, suggesting imaging geometry rather than tissue.

Conclusions

- Endoscopic DOCI detected a consistent scar-vs-normal difference in 8-week VF scar, with no difference at baseline.
- Earlier variability tracks image quality and active healing; standardized acquisition should sharpen the signal.
- Supports DOCI as a noninvasive, label-free tool for VF scar assessment.