Optical clearing efficiency estimation in visualization of ICG-labeled polymer implants

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Motivation

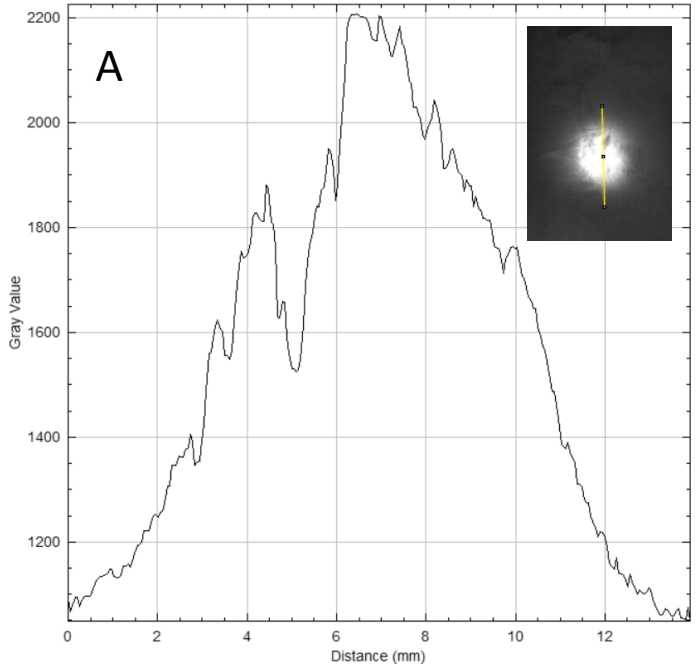
Understanding the processes related to the degradation of polymer implants and their interaction with optical clearing agents is crucial for medical practice. Optical clearing can enhance the visualization of subcutaneous formations and improve diagnostic and therapeutic accuracy. Our study aims to evaluate the efficiency of optical clearing of the fluorescent signal in polymer implants using a glycerol solution.

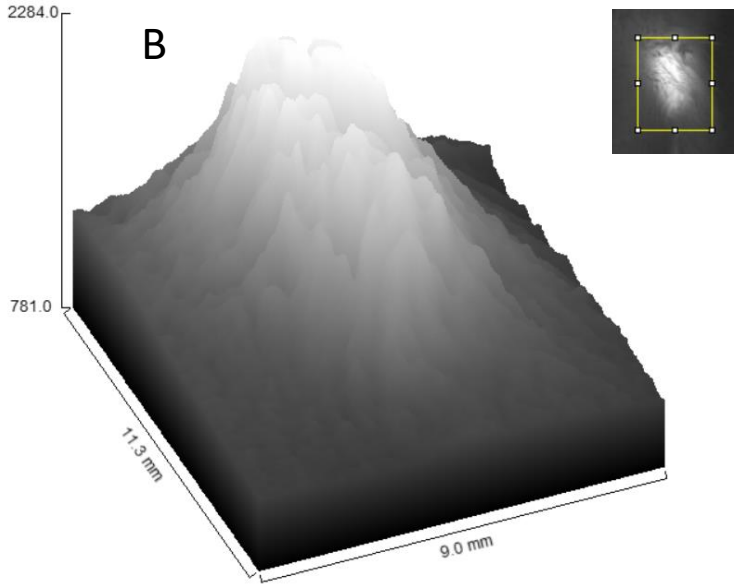
Materials and Methods

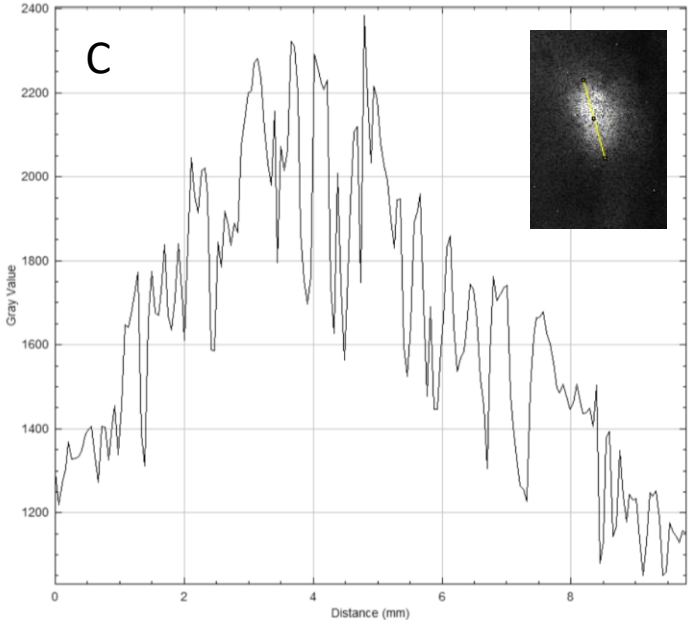
The experiment was conducted on mice, into which polymer discs (5 mm in diameter) labeled with the fluorescent dye ICG were implanted subcutaneously. Optical clearing was performed using a 70% aqueous glycerol solution over a period of 10 minutes. Fluorescent images were captured at specific intervals (0, 15, and 30 minutes) post-application of glycerol.

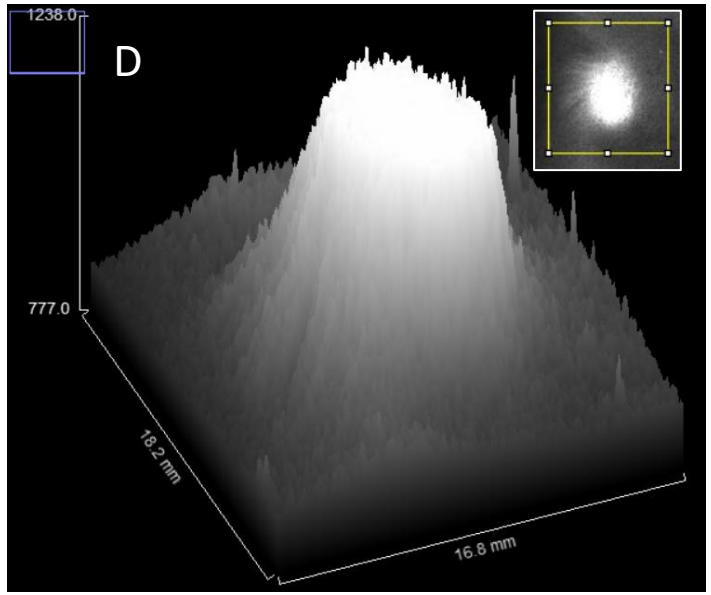
The images were analyzed using ImageJ (Fiji) software. Regions of interest containing ICG and adjacent skin areas were selected for noise level assessment. The data were used to construct graphs depicting the fluorescent signal and its changes over time.

Results



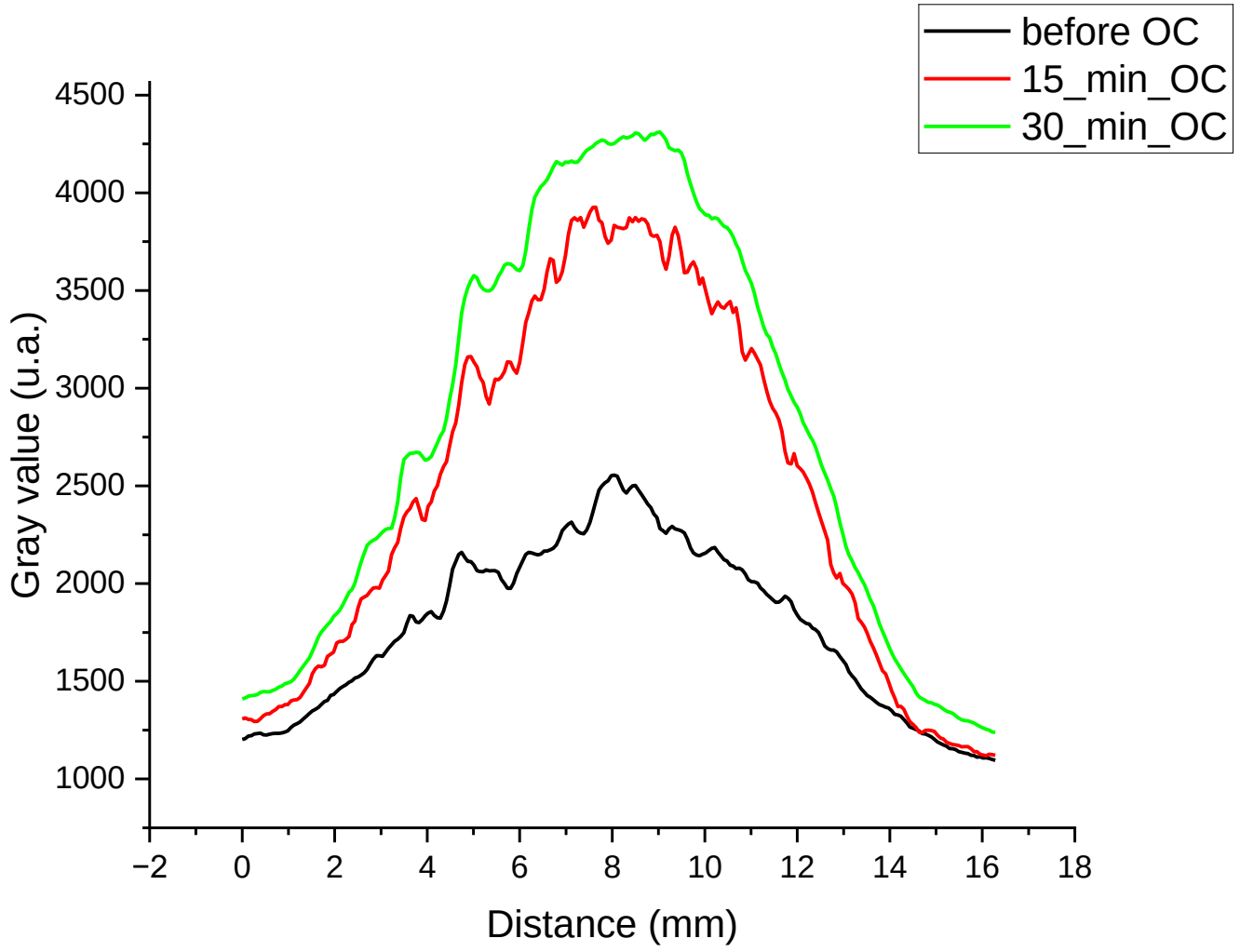






A - Profile of fluorescence from the polymer disk after the application of the clearing agent on the mouse's skin.
B - 3D profile with the application of the clearing agent.
C - Profile of fluorescence from the polymer disk without the application of the clearing agent on the mouse's skin.
D - 3D profile without the application of the clearing agent.

Results



•In most cases, the FI profile in weakly fluorescent polymers (<2000 a.g.) in intact tissues was aligned at 0 min and 15 min after OCA application.

•In some instances, a decrease in fluorescence signal was noticed between 0 and 30 min, especially when skin lesions occurred, potentially due to dye quenching in glycerol as shown in previous studies.

•Most polymer implants degraded in the body over 28-40 days.

• The fluorescent signal primarily demonstrated a decrease over time, though occasional spikes were observed on days 10-14.

• Maximum signal stability was recorded at 0 minutes (glycerol on the skin for 10 minutes).

•A correlation between glycerol exposure time and signal level was noted: as exposure time increased, the fluorescent signal increased by an average of 10-15%.

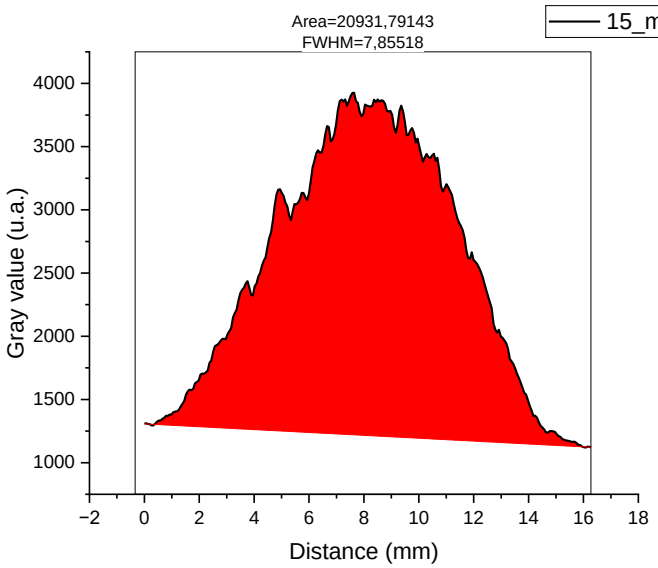
Results: Optical clearing efficiency

$$Q = \frac{\int_a^b F_{\text{after}}\,dx - \int_a^b F_{\text{before}}\,dx}{\int_a^b F_{\text{after}}\,dx + \int_a^b F_{\text{before}}\,dx}$$

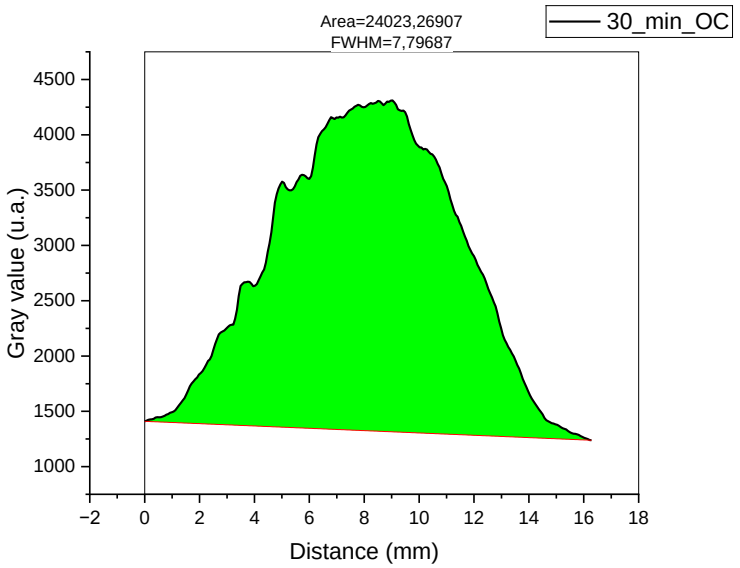
Q-Optical clearing efficiency

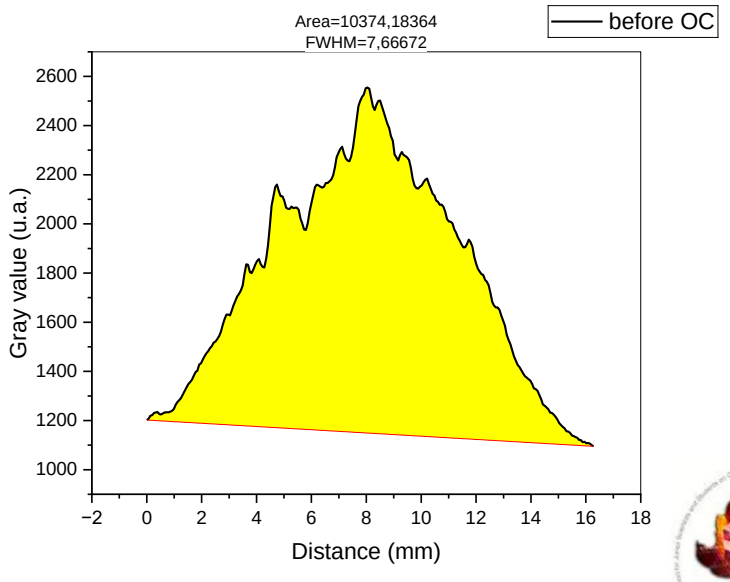
•In most cases, the FI profile in weakly fluorescent polymers (<2000 a.g.) in intact tissues was aligned at 0 min and 15 min after OCA application.
•The fluorescence optical clearing (OC) efficiency was calculated based on the integral areas of the fluorescence signal, ranging from negative values to 40%.
• On day 7, the third mouse, when exposed to the clearing agent for 15 minutes, showed a clearing efficiency of 33.72%.
•On day 7, the third mouse, when exposed to the clearing agent for 30 minutes, showed a clearing efficiency of 39.68%.

Q=0,3372



Q=0,3968





Conclusions

The efficiency of optical clearing of the fluorescent signal in polymer implants can be assessed through changes in fluorescence intensity. The experiment demonstrated a correlation between glycerol exposure time and signal stability, which may facilitate the assessment of skin condition in experimental animals. These findings can aid in optimizing the application of optical clearing to enhance visualization of subcutaneous formations and other medical purposes.