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Sutureless Implantation of Acoustic Transmitters in Rainbow Trout Exceeding 2% Tag-to-Body Ratio

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Abstract

A novel sutureless surgical technique has been successfully used to implant acoustic transmitters in relatively large rainbow trout *Oncorhynchus mykiss* with a tag-to-body-ratio of 0.88%. This study examined the same technique in smaller rainbow trout in two, 12-week trials comparing both sutured and sutureless surgical techniques. In the first trial using a tag-to-body-ratio of 1.9% ± 0.04%, tag retention was only 16.6% in fish without sutures, which was significantly lower than the 83.3% retention with sutured incisions. Similarly, in the second trial with a tag-to-body-ratio of 3.2% ± 0.03%, tag retention was 55.5% without sutures, which was significantly lower than the 90.0% retention using sutures. Mortality was not significantly different between treatments in either trial. The results of this study indicate that sutures must be used during surgeries to implant acoustic transmitters in relatively smaller fish with tag-to-body-ratios at or above 1.9%.

Keywords

Rainbow Trout, *Oncorhynchus mykiss*, Surgery, Acoustic Transmitter

1. Introduction

Electronic transmitters are widely used to study fish behavior, spatial ecology, and survival [1] [2] [3] [4] [5]. They can be attached externally, inserted into the gastric system, or inserted into the body cavity [6] [7] [8] [9]. The most common method of acoustic transmitter insertion is via a ventral incision closed by two sutures [10]. However, Kelican *et al.* [11] recently used a novel sutureless technique to close the ventral incision and achieve 100% tag retention in large rainbow trout with a tag-to-body ratio of 0.88%.

Winter [12] suggested that acoustic transmitter weight should not exceed 2% of fish body weight. Although this recommendation has been a widely used guideline in the application of fishery and biological science [13], several studies have shown positive results at ratios well beyond 2%. In general, salmonids with tags up to 10% of body weight in the Columbia River showed no long-term negative effects on swimming performance and predator avoidance [14] [15]. Rainbow trout *Oncorhynchus mykiss* showed no significant impairment with tags ranging from 6% - 12% of body weight [16]. Ammann *et al.* [17] showed no difference in growth rates, survival, or tag retention in Chinook salmon *Oncorhynchus tshawytscha* with tags ranging from 2.6% to 5.6% of their body weight.

While the sutureless surgical technique for transmitter implantation used by Kelican *et al.* [11] was successful with relatively large fish, there are no studies examining its utility with smaller fish, particularly those exceeding the 2% threshold identified by Winter [12]. Thus, the objective of this study was to determine the effects of sutureless hydroacoustic transmitter implantation on smaller rainbow trout with tag-to-body-ratios near or above 2%.

2. Materials and Methods

This experiment was conducted at McNenny State Fish Hatchery (rural Spearfish, South Dakota, USA) using well water (11˚C; total hardness as $CaCO_3$, 360 mg/L; alkalinity as $CaCO_3$, 210 mg/L; pH 7.6; total dissolved solids, 390 mg/L). Two trials, each lasting 12 weeks, used dummy acoustic transmitters (9 × 24 mm, 3.6 g weight in air, VEMCO, Belford Novia Scotia, Canada). Two treatments were used in each trial: 1) acoustic transmitter inserted via ventral incision closed with two sutures, and 2) acoustic transmitter inserted via ventral incision with no sutures (un-sutured). In Trial 1, 24 Shasta-strain rainbow trout (mean ± SE initial length and weight = 264 ± 1 mm and 195 ± 3 g, respectively) with a tag-to-body ratio of 1.9 ± 0.04% were used (n = 12). Trial 2 used 24 Gerrard strain rainbow trout (mean ± SE initial length and weight = 225 ± 1 mm and 114 ± 1 g, respectively) with a tag-to-body-ratio of 3.2% ± 0.03%.

Before undergoing surgery, each fish was brought to stage IV anesthesia [18] with 60 mg/L Tricaine Methanesulfonate (MS-222, Syndel, Ferndale, Washington, USA), weighed to the nearest gram, and measured to the nearest millimeter. All surgeries were performed by an experienced surgeon [19]. Each fish was placed in a V-shaped foam trough, where their gills were constantly flushed with water containing anesthetic. Once placed in the trough, a 10-mm incision was made into the peritoneal cavity 3 mm from the mid-ventral line and just cranial to the pelvic groove. The incision was made just large enough to insert a dummy acoustic transmitter into the peritoneal cavity. Each transmitter was soaked in iodine for disinfection prior to insertion. For the sutured treatment groups in each trial, two absorbable sutures (Oasis Nylon Monofilament sutures, 4-0, Glendora, California, USA) were placed in a simple interrupted pattern to close the surgical incision. All fish were placed in a recovery tank immediately after surgery.

Following recovery, the fish from each trial were placed in a covered concrete raceway (4.7 m long × 2.4 m wide and 0.5 m deep) for the duration of the experiment. One-day post-surgery, the fish were fed (4.5 mm floating Oncor 80, Skretting, Tooele, Utah, USA) daily at a rate slightly above satiation. Dissolved oxygen in the raceway was maintained above 6.0 mg/L.

Fish in both trials were monitored for survival and tag retention. The raceways were checked daily for expelled tags. At the completion of the study, each fish was administered a lethal dose of MS-222 and underwent necropsy to evaluate tag retention. Any fish that died before the end of the study was also necropsied. The following formulas were used for analysis:

$$\text{Tag retention}(\%) = 100 \times (\text{fish retaining tags}/\text{initial fish tagged}). \quad (1)$$

$$\text{Survival}(\%) = 100 \times (\text{fish alive at end of study}/\text{initial number of fish}). \quad (2)$$

Data were analyzed using SPSS (24.0) statistical analysis program (IBM, Armonk, New York, USA). Chi-square analysis was used to determine differences between treatments for survival and tag retention. Due to the small sample sizes in each trial, significance was pre-determined at $p = 0.1$.

3. Results

Survival was not significantly different between the unsutured and sutured treatments in either trial (Table 1). Tag retention was significantly higher for the sutured treatment (83.3%) compared to the un-sutured treatment (16.6%) in Trial 1 (Table 2). Eight of the nine un-sutured fish that lost a tag did so by week 5. Similarly, tag retention was significantly different between sutured (90.0%)

Table 1. Survival rate (%) for rainbow trout *Oncorhynchus mykiss* in two trials testing surgical implantation of acoustic transmitters in fish with and without sutures (n = 12, $p = 0.1$).

Trial (tag-to-body ratio)		Survival (%)	*p*-value
1 (1.9%)	Sutured	100.0	0.33
	Un-sutured	92.0	
2 (3.2%)	Sutured	83.3	0.63
	Un-sutured	75.0	

Table 2. Tag retention (%) for rainbow trout *Oncorhynchus mykiss* in two trials testing surgical implantation of acoustic transmitters in fish with and without sutures (n = 12, $p = 0.1$).

Trial (tag-to-body ratio)		Retention (%)	*p*-value
1 (1.9%)	Sutured	83.3	0.00
	Un-sutured	16.6	
2 (3.2%)	Sutured	90.0	0.09
	Un-sutured	55.5	

and un-sutured (55.5%) treatments in Trial 2. Tag loss in the unsutured fish occurred in weeks 1, 3, 4, and 11. Necropsies indicated that mortality was not caused by handling or surgery.

4. Discussion

The results of this study indicate the importance of using sutures for a ventral incision after placing an acoustic transmitter into the peritoneal cavity of rainbow trout when the tag is at or exceeding 2% of fish body weight. This supports the widely accepted method of placing acoustic transmitters in a ventral incision closed with two sutures [8] [10]. However, sutures may not be needed at tag-to-body-ratios of less than 1% [11]. Additional research is needed to determine the inflection point between 1% and 2% tag-to-body-ratios when sutures are essential for tag retention using ventral incisions.

Sutureless lateral incisions have also been used to implant acoustic transmitters in rainbow trout at tag-to-body ratios of 1% [11] [20] [21]. This technique uses a small incision in the lateral body wall of the abdominal cavity, just large enough for transmitter insertion. While complete wound closure time was approximately two weeks longer than traditional sutured methods, tag retention was successful and there was little to no wound inflammation [11] [20] [21]. It would be beneficial to test this method on relatively smaller fish with much higher tag-to-body-ratios [11] [20] [21].

The high survival rates in this study were comparable to that of other studies using both wild and hatchery origin rainbow trout. Schreck *et al.* [15] did not observe differences in survival of wild salmonids implanted with transmitters at ratios ranging from 0.3% to 9.9% of their body weight. Urbaniak *et al.* [22] reported 60% survival for rainbow trout held in captivity. Similarly, Bunnel and Isely [23] reported 75% to 93% survival in acoustic tagged rainbow trout.

Since this study was conducted in a controlled hatchery setting, the results may not be directly applicable to fish directly released into natural environments. However, the Gerrard strain is relatively undomesticated, unlike the Shasta strain [24] [25] [26] and the results were similar for each strain in this study. The relatively small sample sizes could also have potentially affected the results, although this is unlikely given the large differences between the treatment groups [27]. This study should be relevant to other salmonid species because rainbow trout are considered a model study species [28].

In conclusion, this study using sutureless ventral incisions supports the 2% tag-to-body-ratio recommended by Winter [12]. Given the potential fish health and healing benefits of not using sutures [11] [20] [21], additional research is needed to determine how high the tag-to-body-ratio can be during both ventral and lateral unsutured transmitter implantation without impacting tag retention.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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