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ORIGINAL PAPER

Mechanical tools for the removal of *Ixodes ricinus* female ticks— differences of instruments and pulling or twisting?

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Abstract The fast and safe removal of ticks is of medical and veterinary importance since many tick-borne pathogens require time to be transmitted. In the past, many tools and applications were used to remove ticks from the skin of humans and pets. Choking the ticks by blocking their respiratory system with chemicals cannot be recommended due to the low respiratory rate of ticks. Mechanical devices to remove ticks are usually recommended; however, they vary with regard to their mechanism of seizing and holding the tick and in the way of extraction (pulling or twisting). In this study, five commercial tick removal devices with different mechanisms were tested on pets according to their practicability, injury of the mouthparts, and the idiosoma of female Ixodes ricinus ticks. Therefore, 22 veterinarians and four pet owners removed 596 ticks from various animals by using the different devices and filled in a questionnaire for each case. The tick species and instars were determined, and for the female I. ricinus ticks (n0527) the condition of the mouthparts as well as the idiosoma was evaluated. Twisting of the female I. ricinus ticks reduced the force required for extraction, the adverse reaction of the animal and the time needed for removal. The device with a "V"-shaped slot which allows a grabbing of the mouthparts delivered the best results according to the condition of the mouthparts and the intactness of the female I. ricinus tick's body. Therefore, grabbing the mouthparts and twisting can be recommended for removal of I. ricinus females from pets.

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Introduction

Due to the ability of ticks to transmit a variety of diseases to humans and pets, especially after prolonged blood feeding, fast and safe removal is an important method to prevent transmission of many pathogens. This is especially important for e.g. Borrelia which requires at least 16 h of feeding for transmission (Kahl et al. 1998), Anaplasma with 24 h (des Vignes et al. 2001) or Babesia with at least 48 h (Heile et al. 2007). Those pathogens are known to represent a threat for pets especially dogs (Földvári et al. 2007; Pantchev et al. 2009). For tick removal, a wide range of tools can be applied, including chemicals and mechanical treatment. In general, all techniques prolonging the time period of attachment, and consequently the risk of transmitting pathogens, should be avoided. Especially the use of chemicals such as petroleum jelly, oil or glue, which choke the ticks cannot be recommended. Ticks open their respiratory system a few times per hour for some minutes (Knülle and Rudolph 1982; Teece and Crawford 2002). Ticks survive from several days up to weeks under the water (Dautel et al. 2011), and killing ticks by blocking the spiracles and the respiratory system, causing detachment, usually takes too long to be effective (Needham 1985). In addition, ticks treated this way may react with increased salivation and regurgitation of saliva into the wound (De Boer and van den Bogaard 1993; Schwartz and Goldstein 1990), which increases the risk of pathogen transmission. For the same reason, squeezing during mechanical removal should be avoided (De Boer and van den

Bogaard 1993), and the same accounts for burning, because the heat stress might induce regurgitation into the wound, or the tick bursts, releasing pathogens into the wound (Needham 1985).

For mechanical removal, shaving (Möhrle 2002), pulling (Wiedemann 2003) or rotation (De Boer and van den Bogaard 1993) with many different devices can be applied. To date, it is not clear if manipulation of the tick's body (e.g. squeezing) increases the risk of transmitting pathogens. Möhrle (2002) believes that ticks should not be stressed in any way and the best removal is to cut the hypostome by using a shaver, leaving the chitinous part inside the skin. Other authors (Gammons and Salam 2002; Needham 1985; Theis 1968), however, insist on the total removal of all parts of the tick. Alekseev and colleagues (1996) detected an accumulation of Borrelia bacteria in the cement-like material in the wound after 18–22 h of attachment and therefore recommend to remove all tick parts.

Kahl and colleagues (1998), and Piesman and Dolan (2002) found no difference in the transmission rate of Borrelia between ticks that were crushed and those that were removed with gentle pressure. De Boer and van den Bogaard (1993), and Zenner and coworkers (2006) suggest leaving the small mouthparts in the skin since severe secondary reactions are unlikely and no infectious parts are left behind. Additionally, the latter studies recommend rotation while removing ticks (Ixodes ricinus) because the force on the tick was reduced compared to pulling and the parts of the hypostome left in the skin were smaller. On the other hand, the hypostome is not built like the thread of a screw and therefore pulling is preferred by some authors (Wiedemann 2003) since rotation increases the chance to wring the tick and might lead to regurgitation. Needham (1985) focused on the fixation of the mouthparts and not the direction of the extraction.

Previous studies do not permit a direct comparison of techniques because different tick species and different developmental stages were used. Tick species vary enormously in the length and shape of the hypostome (Needham 1985; Theis 1968) and differ greatly in size during development.

The most common mechanical devices can be put into three different groups according to the ways of holding the tick and the direction of extraction. Ticks can be grabbed by the use of (a) opposing jaws, (b) V-shaped slots or (c) strings. Once the tick is held by the device, it can either be extracted by pulling or twisting.

The aim of this study was to compare five different commercial tick removal devices with different mechanisms in terms of their handling, practicability, usefulness and quality of removal as evaluated by the female I. ricinus tick's mouthparts and body injury under field conditions on pets.

Fig. 1 Overview of the five tick removal devices used in this study: pen-tweezers (a), the Tick Twister® (b), "lasso", i. e. Trix® tick remover (c), adson forceps (d) and "card", i. e. TickPic (e)

Materials and methods

Five commercial devices were compared: "forceps", i. e. adson forceps (Sagalain Intl., Pakistan); "card", i. e. TickPic (Fact Solution GmbH, Germany);"lasso", i. e. Trix® tick remover (Innotech Healthcare AB, Sweden); the Tick Twister® (O'Tom® H3D, France); and pen-tweezers (WDT, Germany) (Fig. 1.; Table 1). These devices were tested by 22 veterinarians and four persons used to removing ticks from pets. The devices were handed out to the participants with form to evaluate the time needed to extract, how easily the tick could be grabbed, the force needed to remove the tick, the reaction of the animal, and the ease of handling (Table 2). The use of each device was chosen by the participants in random order, and they were instructed to remove five ticks with each device. The ticks were placed in pre-numbered 2-ml tubes filled with 70 % ethanol for identification of stage, species, condition of the mouthparts and degree of squeezing (Table 2), which was evaluated under the stereomicroscope at × 7.5–40 magnification after submission to

Table 1 Devices used for the extraction of ticks

Device	Grabbing mechanism	Operating
Pen-tweezer	Jaws	Twisting
Tick twister®	V-shaped slot	Twisting
Lasso	String	Twisting
Forceps	Jaws	Pulling
Card	V-shaped slot	Pulling

Table 2 Evaluation schedule for removing (items I–V) and analysing (items VI, VII) the female I. ricinus ticks

Item		Grade 1	2	3	4
I	Reaction of the animal	None	Animal turned its head	Whined or growled once	Whined or growled several times or attempted to bite
II	Time required to remove	<15 s	15–30 s	30–60 s	>60 s
III	Ease to grab the tick	Very easy	Easy	Awkward	Difficult
IV	Force needed to extract	None	Gentle	Moderate	Considerable
V	Use of the device	Very easy	Easy	Awkward	Difficult
VI	Condition of mouthparts	Mouthparts intact	Hypostome partially severed (at least one denticle can be seen)	Hypostome severed at the base (chelicers present)	Mouthparts (including chelicers) severed
VII	Squeezing	None	Slightly	Massive	–

Items I–IV, VI and VII according to Zenner et al. (2006)

the Institute of Parasitology at the University of Veterinary Medicine Vienna.

Because the shape and length of the mouthparts vary between stages and species, only the data set from the largest group, I. ricinus females, was statistically evaluated with PASW 17.0 (SPSS Inc., Chicago, Illinois). Analysis was performed by using the Kruskal–Wallis test and the Mann–Whitney test for pairwise comparisons. The level and time of engorgement was calculated by determining the scutal index and applying regression equations (Gray et al. 2005). The ticks were divided into two groups being attached for less or more than 96 h.

Results

A total of 596 removed ticks were received including 541 I. ricinus, 40 Ixodes hexagonus, two Haemaphysalis concinna, one Dermacentor reticulatus, one Rhipicephalus sanguineus and 11 unidentified specimens damaged during removal. Out of the 541 I. ricinus, 527 were identified as females. Only these were included in further calculations. These I. ricinus females were sampled from 320 dogs, 198 cats, six hedgehogs, one guinea pig, and for two no information on the host was provided. The forceps were used 90 times, the card 100 times, lasso and Tick Twister® 108 times each, and the pen-tweezers 121 times.

The twisting devices (lasso, Tick Twister®, pen-tweezers) provided a relatively higher amount of partly severed hypostomes, whereas the pulled ticks (forceps and card) showed nearly equal numbers of ticks with the mouthparts intact or with a severed hypostome (Fig. 2). Twisting resulted in less effort ($p<0.001$) and shorter time ($p<0.001$) compared to pulling (Fig. 3a, b). The animals showed significantly ($p<0.001$) fewer reactions when ticks were removed by twisting (Fig. 3c). In all, the devices failed 10 times (card: nine; Tick Twister®: one).

The pen-tweezers were ranked best when comparing all mean values, followed by the lasso and the Tick Twister® (Table 3). Regarding the intactness of the mouthparts and the tick's body, the Tick Twister® was evaluated best (Table 3, Figs. 4 and 5). Comparing the difference in the intactness of the mouthparts, the Tick Twister® was significantly better than forceps and lasso (Table 4), and it also

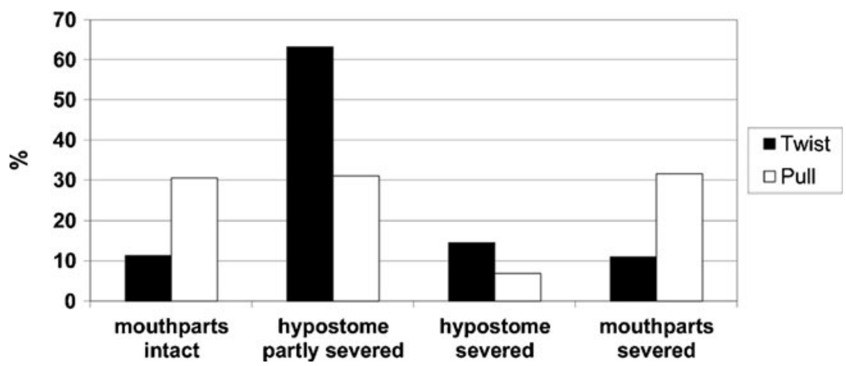

Fig. 2 Condition of the mouthparts of the I. ricinus females after removal by twisting or pulling

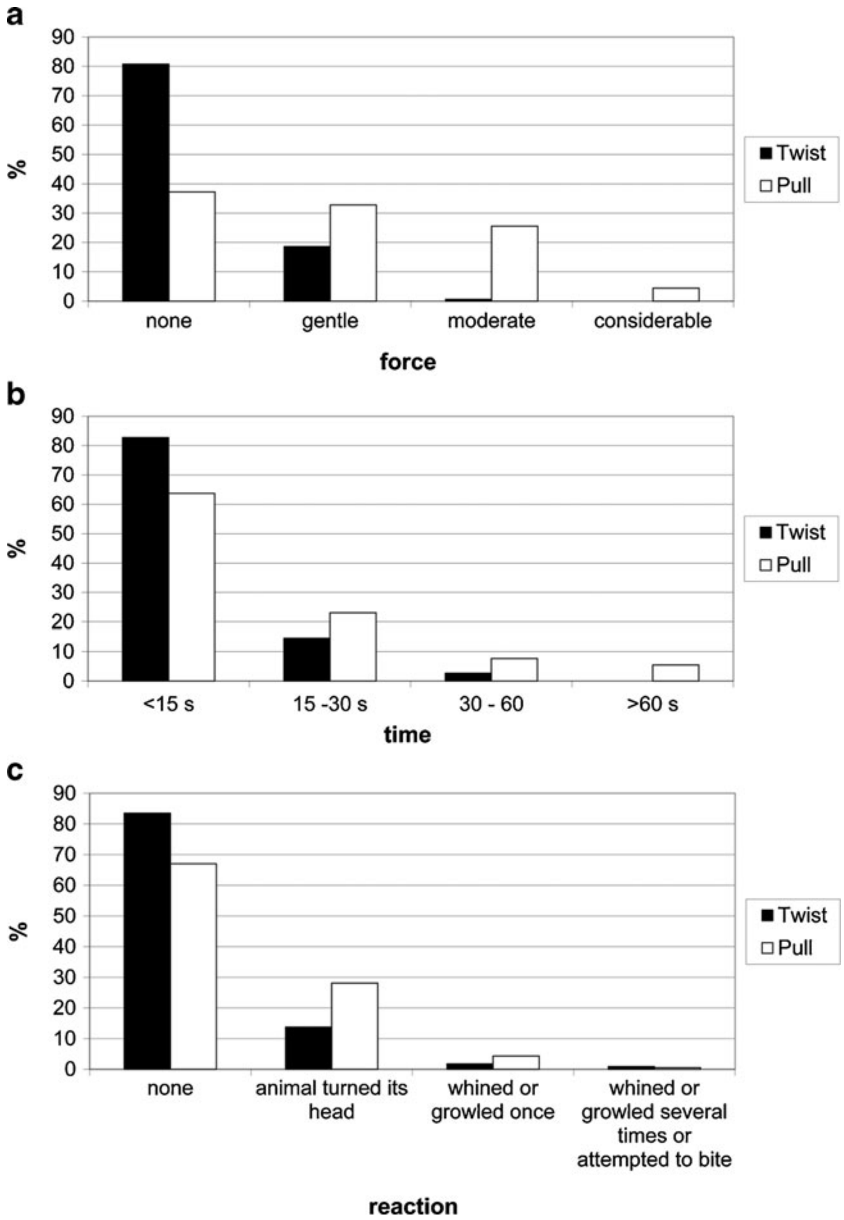

Fig. 3 Differences between pulling or twisting of the female I. ricinus ticks for extraction in relation to force (a) and time (b) needed to extract as well as the reaction (c) of the animal host during removal

Table 3 Ranking of the devices by the mean values filled in the questionnaire (I–V) or defined by microscopy (VI, VII)

Item		Pulling		Twisting		
		Forceps	Card	Lasso	Tick Twister®	Pen-tweezer
I	Reaction of the animal	5	4	2	3	1
II	Time required to remove	4	5	2	3	1
III	Ease to grab the tick	4	5	2	3	1
IV	Force needed to extract	4	5	1	2	2
V	Use of the device	4	5	2	3	1
VI	Condition of mouthparts	5	3	4	1	2
VII	Squeezing	4	3	2	1	5
	Total	4.3	4.3	2.1	2.3	1.9

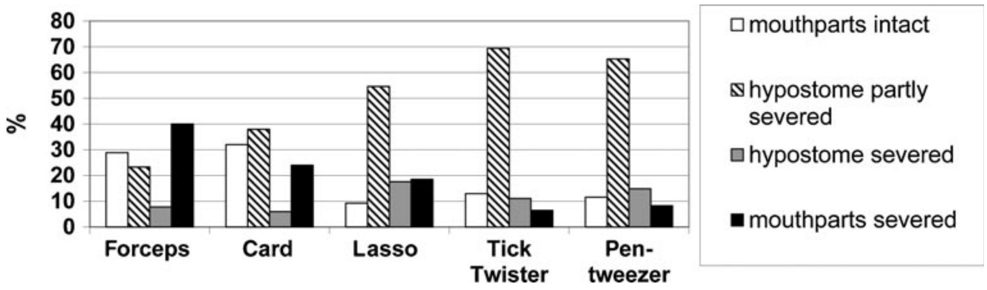

Fig. 4 Condition of the mouthparts of the female I. ricinus after using the different devices

delivered significantly less crushed parasite bodies compared to the forceps, card and pen-tweezers (Table 5).

According to the calculations of the scutal index and the level of engorgement, 45.2 % of the female I. ricinus ticks were removed after less than 96 h of attachment, whereas 53.7 % had been attached for longer than 96 h. For the remaining 1.1 % of the female I. ricinus ticks, the index could not be calculated.

Discussion

Although the available methods for mechanically removing ticks vary, and the opinions concerning the appropriate technique, i.e. pulling vs. twisting, and the importance of the hypostome remaining in the wound greatly diverge, there is consensus regarding the importance of removing ticks as soon as possible (des Vignes et al. 2001; Heile et al. 2007; Stewart et al. 1998). When looking at the condition of the mouthparts of the female I. ricinus ticks, the force and time needed for removal, and the reaction of the animal, the twisting methods are preferable over pulling. This is in concordance with some other studies (De Boer and van den Bogaard 1993; Zenner et al. 2006). Rotation seems to require less force, and though breaking of the hypostome was more frequent, the part left in the wound was shorter than in of the female I. ricinus ticks removed by pulling. This is certainly preferable to leaving most of the mouthparts in the host skin, since the small pieces (tips of the hypostome) do not harbour pathogens and are supposed to cause no major tissue reaction (Zenner et al. 2006). Damaging the tick's idiosoma might increase the risk of injecting pathogens, e.g. rickettsia, into the wound (Piesman and Dolan 2002). Therefore it can be recommended—similar to the shave excision (Möhrle 2002)—to accept a break of the tip of the hypostome instead of taking the risk to crush the tick during pulling. The reduced force needed for twisting may be the reason for the decreased reaction of the animals, since more force might increase the pain or at least cause discomfort for the animal. Furthermore, less time is needed to extract the female I. ricinus tick when rotation is used, increasing practicability. Maybe rotation reduces the resistance of the hypostome, which is armed with numerous backward-facing denticles, thus facilitating removal of the tick (Zenner et al. 2006).

The test persons voted for the pen-tweezers as their favourite, and except for the force needed for extraction, the mouthparts and the body injury, this device was ranked first. The high acceptance is probably due to the fact that this is the most common device used in Austria. The other devices, especially the lasso and the Tick Twister® were new to most of the participants and the handling surely was unfamiliar.

With regard to the extent of mouthpart injuries, the Tick Twister® ranked best. V-shaped slots and rotation seem to be more suitable than jaws and traction with regard to that parameter (Zenner et al. 2006). Such devices grab the mouthparts in the V-shaped slot right at the base and the tick can be removed more or less intact. In contrast, cutting of the mouthparts was observed when applying a V-shaped slot for the removal of adult lone star ticks (Stewart et al. 1998), while the technique was more suitable for nymphs.

Regarding the extent of idiosoma injury, the Tick Twister® also had the lowest rate of injured female I. ricinus ticks. The pen-tweezers are probably too big to gently grab the I. ricinus tick's mouthparts (Zenner et al. 2006). The lasso seems to

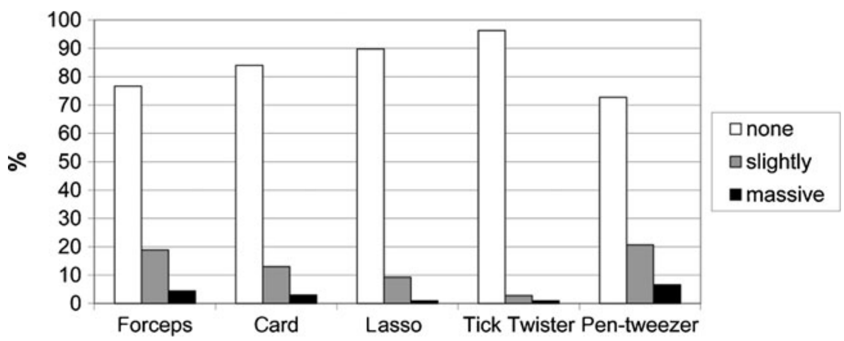

Fig. 5 Idiosoma injury of the female I. ricinus ticks in relation to the device used for extraction

Table 4 p Values of the pairwise comparison of devices regarding the condition of the mouthparts of the female I. ricinus ticks

	Card	Lasso	Tick Twister®	Pen-tweezer
Forceps	0.06	0.64	0.03*	0.07
Card	–	0.02*	0.72	0.36
Lasso	–	–	<0.001**	0.03*
Tick Twister®	–	–	–	0.36

*p<0.05; **p<0.01

mostly damage the female I. ricinus only slightly. It grabs the tick by tightening a string around the edentation between the idiosoma and the capitulum, only applying pressure to the side of the tick. The forceps—especially when used for engorged female I. ricinus ticks—is not able to grab the mouthparts without harming the engorged body. The card—due to its V-shaped slot—grabs the ticks at the basis of the capitulum, but according to the statements of the participants, the ticks tend to slip through the slot and are squeezed.

There is a significant difference in removing ticks from animal or humans. Ticks found on pets are probably in a more advanced stage of engorgement because they might be missed in the hair coat when they are still small. However, it is important to remove the ticks as soon as possible, because the transmission of other pathogens like Babesia or Anaplasma starts after 48 and 24 h, respectively (des Vignes et al. 2001; Heile et al. 2007). Shave excision (Möhrle 2002) would be suitable but is hardly feasible on pets, especially these with dense coats and an abundance of ticks.

Removing ticks from pets is dependent on the temperament of the animal, the location of the tick, the coat of the animal and individual preference of the person removing them. If possible, rotation and a V-shaped slot device should be preferred. The V-shaped part grabs the tick at the base of the mouthparts and avoids wringing of the tick's body. Twisting could cause troubles when the coat is too dense. Nervous pets sometimes impede accurate fixation of the tick. In such cases, the lasso might be helpful, since catching the tick with the string on a nervous pet requires less force. The ticks then could be removed without any further manipulation of the pet's skin.

Table 5 p Values of the pairwise comparison of devices for the intactness of the female I. ricinus tick's body

	Card	Lasso	Tick Twister	Pen-tweezer
Forceps	0.21	0.01*	<0.001**	0.49
Card	–	0.20	<0.001**	0.04*
Lasso	–	–	0.07	<0.001**
Tick Twister®	–	–	–	<0.001**

*p<0.05; **p<0.01

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