Microchipping of Animals

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Animal microchip types and frequencies

Implantable microchips are cylindrical devices that are implanted in the subcutaneous tissues using a hypodermic needle. The devices are battery-free and sealed in biocompatible glass covered by a sheath to prevent migration. Microchips are activated by a low-power radiofrequency signal emitted by scanners. When activated by the scanner, the microchip transmits a unique, preprogrammed identification number.[1,2] Some microchips used in animal research also collect and transmit body temperature data.[3]

Microchips are produced by various manufacturers within the U.S. and other countries. Radio Frequency Identification Device (RFID) microchips are implanted in animals.

Differences in animal microchip frequency in the US have led to controversy and several civil lawsuits.[2,4,5] There is no agreed-upon "American standard" for microchip frequencies.[5] The American National Standards Institute (ANSI) voted in favor of the current ISO Standards both at the time of initial adoption in 1996 and at the time of their mandatory 5-year review in 2001 and 2006. In its August 2006 report to USDA, the Equine Species Working Group urged use of the ISO standard for identification of equine species, as well as the development of ISO-compliant scanners that are also able to read, or at least detect, 125-kHz microchips.[6]

The International Standards Organization (ISO) standards 11784/11785 were implemented in 1996.[7] They are accepted by Canada, Europe, Asia, and Australia, and have been endorsed for use in the United States by the American National Standards Institute (ANSI). ISO standard 11784 defines the structure of the microchip information content, and standard 11785 determines the protocol for scanner-microchip communication.[8] The standards include the assignment of a 15-digit numeric identification code to each microchip: 3 digits of the identification number designate either the 3-digit country code of the country in which the animal was implanted (The Country code is used only if there is a central, national database that takes on the responsibility of administering number allocation and ensuring no number duplication) or the 3-digit manufacturers code (as assigned by the International Committee on Animal Recording [ICAR]) if there is no central, national database, to ensure number uniqueness; 1 digit denotes the animal's category (optional); and the remaining 8- or 9-digits denotes a unique animal identification number. In 2005, a dog was reunited with its owner in Toronto, Canada after its ISO microchip number was traced to its original registration in Portugal.[8] Non-ISO standard (125- or 128-kHz) microchips contain 9 or 10 digits and do not include a country code. Manufacturer codes are assigned by ICAR following an application and review process that includes signing a "code of conduct." A list of Manufacturer Codes can be found at on the ICAR site.

Commonly available microchips implanted in pets in the U.S. include the following:

125-kHz microchips:
24PetWatch® (unencrypted)
FriendChip®, Avid (encrypted)
HomeAgain®/Digital Angel (unencrypted)

128-kHz microchips:
AKC Companion Animal Recovery® (AKC CAR®)

134.2-kHz microchips:
Bayer ResQ®
HomeAgain®/Digital Angel

Animal microchipping in the United States and other countries

The ISO approves 134.2-kHz as the standard frequency for animal microchips, but 125-kHz, non-ISO microchips remain the predominant microchip frequency used within the US at this time. In recent years, additional 128-kHz and ISO-compliant 134.2-kHz microchips have been introduced.[9] The American Veterinary Medical Association (AVMA), American Animal Hospital Association (AAHA), World Small Animal Veterinary Medical Association (WSAVA), and American Society for the Prevention of Cruelty to Animals (ASPCA) endorse the use of electronic identification in animals and support the implementation of ISO standard 11784/11785 in the U.S. The AVMA's policy on "The Objectives and Key Elements Needed for Effective Electronic Identification of Companion Animals, Birds, and Equids" states "The AVMA endorses the use of electronic identification in animals and supports the standardization in materials, procedures, equipment, and registries. Veterinarians are thereby encouraged to recommend the use of electronic identification of animals to their clients." The implementation of a global system of animal identification has the potential to eliminate geographical boundaries that might interfere with animal recovery.

At this time, microchipping of pets and other animals is voluntary in the U.S. except for some legislation mandating microchipping as a means of identifying animals who have been identified as being dangerous. In 1994, the Louisiana Department of Agriculture and Forestry (LDAF) issued a regulation requiring permanent identification (in the form of a brand, lip tattoo or electronic identification) of all horses tested for equine infectious anemia (EIA).[10] According to the LDAF and the state veterinarian, this requirement was "a significant help" in determining the owners of horses displaced during Hurricane Katrina in fall 2005.[10,11]

Language was inserted into the 2005 Agriculture Appropriations Bill supporting the use of microchip implantation in pets for identification purposes. As a result, Congress directed the US Department of Agriculture Plant Health and Inspection Service (USDA-APHIS) to develop regulations for microchip identification of pets. In July 2007, the USDA-APHIS released a report to Congress regarding microchipping of pets in the United States. Because the Animal Welfare Act does not authorize the USDA-APHIS to regulate private pet ownership, the organization concluded that it cannot mandate a national standard for pet microchips or scanners.[12,13]

The National Animal Identification System (NAIS) was implemented to protect the health and economic viability of US livestock and poultry.[14] Its primary function is to allow traceability during a foreign animal disease outbreak. At this time, participation in the program is voluntary. A premises identification number (PIN) is assigned to each participating premises, and each animal is assigned an animal identification number (AIN). Animals of the same species that move through the production chain as a group can be assigned a group/lot identification number (GIN). Individual animals can be marked with NAIS-compliant RFID tags or implantable microchips. In 2007, the USDA-APHIS announced its support of ISO standards but remains neutrally positioned on specific identification technology.[12]

A survey conducted by the WSAVA in November 2002 revealed that Western Europe, Australia, and New Zealand had successfully adopted and implemented ISO standards; Eastern Europe, the Middle East, and Asia demonstrated market dominance of ISO-standard microchips; Canada and South America were developing an increased market for ISO-standard microchips; and the U.S. and Africa demonstrated the least development and compliance with the standards.[15]

In December 2004, Canada's National Companion Animal Coalition (NCAC) adopted ISO standards 11784 and 11785 for microchip identification of companion animals. As of August 1, 2005, only ISO standard microchips are recognized by the NCAC as suitable for the electronic identification of companion animals in Canada. ISO standards 11784/11785 are also accepted by Europe, Asia and Australia.[4,16]

In 2006, the European Union (EU) proposed a regulation requiring foals to be microchipped before applying for an equine passport.[17] Currently, an equine passport is required for all horses in EU countries, regardless of their use; this requirement was primarily implemented to prevent human consumption of horses that had received unapproved medications. Present EU regulations do not mandate microchip implantation of horses.

In September 2009, Dogs Trust campaigned for compulsory microchipping of all dogs in the U.K. in response to high reported numbers of stray dogs. The proposed legislation is an amendment to the Statutory Instrument 2006 No. 798, The Dog Control Orders (Procedures) Regulations 2006, The campaign has attained bipartisan support.[18]

Microchip Implantation

The use of standard microchip implantation sites reduces the risk of failure to detect an implanted microchip.[19] As a general rule, the microchip should be implanted in dogs and cats so that its long axis is parallel to the animal's longitudinal axis.[9]

For a list of veterinary-recommended implantation sites in numerous animal species, go to the WSAVA Microchip Web site.

The improper implantation of microchips can result in potentially life-threatening sequelae. The inappropriate, forceful implantation of a microchip by its owner resulted in microchip placement in the spinal canal of a 2-year old cat, causing tetraparesis (weakness of all four limbs) and tachypnea (increased breathing rate). The microchip was surgically removed and the cat recovered, but with residual, mild neurologic deficits.[20] In two separate case reports, inappropriate microchip implantation into the spinal canal of small-breed puppies resulted in acute-onset tetraparesis that gradually resolved following surgical removal of the microchip.[21,22] According to one report, an alpaca died acutely due to the inappropriate implantation of a microchip into its spinal canal.[23]

In the U.K., microchip insertion is not considered a veterinary practice.[22,24,25] The AVMA's "The Objectives and Key Elements Needed for Effective Electronic Identification of Companion Animals, Birds, and Equids" policy states that "implantation of microchips is a veterinary procedure that should be performed by a licensed veterinarian or under supervision of a licensed veterinarian."

Benefits of Microchipping Animals

Permanent, unalterable identification of animals can be a challenge. Although an accepted form of identification, the tattooing procedure can produce discomfort and tattoos can fade with time and can sometimes be altered. Identification tags are effective means of identification only if they are in place on the animal when it becomes lost. Ear tags are effective and visible means of identification, but can be removed intentionally or by trauma. Hot branding provides permanent identification of livestock, but its use in horses elicits a marked pain response followed by local inflammation and increased skin sensitivity for one week.[26] Microchip implantation provides a reliable, and often less painful, method of permanent, unalterable animal identification.

The primary benefit of microchip implantation in pets is the increased chance of reunification of lost or stolen animals with their owners.[27,28] Microchip implantation in horses and other livestock allows increased recovery of stolen animals and traceability in the event of a disease outbreak.

Lord et al[29] determined that the owners of almost three-fourths of microchipped cats and dogs were located due to the presence of the microchip. Owners were more likely to be found for dogs, purebred animals and spayed/neutered animals.[29-33] The rate of return to owners was also higher for microchipped stray animals.[29-33] When compared to a study[30] that determined an owner's efforts were successful in recovering their dog only 13% of the time, the detection of a microchip by an animal shelter yielded a 74.1% rate of return to owners.

Dogs have been reunited with their owners years after they were lost, based on the detection of an implanted microchip.[34-37] Dogs that were found 600 and 1000 miles from their homes were reunited with their owners due to the presence of microchips.[38,39] In 2007, actress Vanessa Williams was reunited with her dog due to the presence of an implanted microchip.[40]

During the response effort to the floods of Hurricane Floyd in 1999, all animals received by the field hospital at the North Carolina State University College of Veterinary Medicine were implanted with microchips to facilitate identification and tracking.[41] One of the recommendations put forth as a result of the 2006 National Animal Disaster Summit is that all animals rescued during a disaster should be implanted with microchips (if not already implanted) to facilitate identification, tracking and reunification with owners.[42] In the aftermath of Hurricanes Katrina and Rita (2005), implanted microchips facilitated the identification of rescued animals.[43]

The Canadian livestock identification process has been driven by the livestock industry, and the mandatory identification system for cattle facilitated epidemiological investigation of bovine spongiform encephalopathy (BSE).[44]

The use of thermal sensing microchips in horses has been promoted as a potential means of monitoring individual animals' body temperatures while decreasing the risk of disease transmission by rectal thermometers shared between multiple animals.[45] Robinson et al[45] determined that the thermal microchips produced more variation in temperature readings than rectal thermometers and the accuracy of the temperatures obtained by the microchip were strongly influenced by the ambient temperature. The thermal microchip over- or underestimated the animal's body temperature and failed to detect more than 50% of fevers in cooler ambient temperatures and approximately 15% of fevers during warmer ambient temperatures. Overall, the thermal sensor detected only 87% of fevers.

Microchip scanners: challenges and efficacy

Detection of the presence of a microchip is the crucial second step of the reunification process (with the first step being implantation of the microchip). A survey-based demographic assessment of animal care and control agencies from 1996 to 2004 revealed an increase in the number of agencies that scanned for microchips upon the animal's arrival in 2004 compared to 1996.[31] In addition, the number of agencies that implanted animals upon adoption increased from 4% to 8% over the same time period.[31]

Market competition and intentional incompatibility between manufacturers' microchips and scanners have led to controversy and lawsuits. According to the USDA-APHIS in 2007, approximately 3 to 5 % of pets within the U.S. are microchipped.[46] Of these, 98% are implanted with 125-kHz microchips. Although there appears to be no independent survey data to verify the claim, the USDA-APHIS letter to Senator Byrd in 2007[46] commented that 80% of microchip scanners in the U.S. read only 125-kHz microchips. As new companies enter the U.S. microchip marketplace, this percentage will change. Two manufacturers currently hold the patent rights on the 125-kHz technology, including the scanners.[47] One manufacturer sells encrypted 125-kHz microchips that can only be read by scanners authorized by that manufacturer; unauthorized scanners might detect the presence of a microchip, but cannot read or display the identification number. Scanners manufactured to detect only 125-kHz microchips cannot read or determine the presence of ISO microchips.[48] Another brand of microchip with 128-kHz frequency has been marketed within the U.S.; this microchip is not detected by some 125-kHz scanners.

According to the Coalition for Reuniting Pets and Families (2005),[49] less than 25% of lost pets in the U.S. are reunited with their owners. In contrast, 47% of lost dogs are reunited with their owners in the United Kingdom, where ISO standard chips are available and a more efficient database is utilized.[49]

Animals traveling to member countries of the European Union (EU) or other countries that have adopted the ISO 11784/11785 standards must be implanted with microchips that meet those standards, or the pet owner may need to carry with them a scanner capable of reading the implanted non-ISO microchip.

The introduction of an ISO standard microchip in the United States in January 2004 underscored the need for scanners capable of detecting ISO and non-ISO microchips (also called 'universal scanners' or 'forward- and backward-reading scanners'). That same year, the controversy surrounding microchip frequency standards gained national attention when a lost pet dog implanted with a 134.2-kHz (ISO) microchip was euthanatized because the animal shelter's 125-kHz scanner did not detect the microchip.[47] Ongoing efforts have been directed at the production of scanners capable of detecting and reading both ISO and non-ISO microchips. In 2007, two companies in the U.S. were engaged in an initial distribution of 50,000 universal scanners.[50,51]

Scanner abilities as reported by manufacturers:

Scanner Name	*125-kHz (E)*	*125-kHz (UE)*	*128-kHz*	*134.2-kHz*
ResQ® (iMax Black Label)	Read	Read	Read	Read
HomeAgain® (Universal WorldScan; Digital Angel)	Read	Read	Read	Read
AKC CAR® (Multi-System Pocket Scanner; Trovan)	Read	Read	Read	Detect Only
Avid (MiniTracker 1 Universal Multi-Scan)	Read	Read	-	-

E= encrypted; UE=uncencrypted

Lord et al[9] tested 3 universal scanners and 1 125-kHz scanner in vitro and determined that even under controlled conditions, none of the scanners were 100% effective in detecting all microchips in all orientations. The universal scanners were able to detect ISO-compliant 134.2-kHz microchips more readily than 125- or 128-kHz microchips. Two of the scanners (HomeAgain® and Avid) were not affected by the orientation of the scanner relative to the microchip's long axis, whereas scanning orientation negatively affected the sensitivity of the AKC CAR scanner for 125-kHz microchips and, to a lesser extent, the Bayer scanner for one brand of 125-kHz and one brand of 128-kHz microchips. The following table summarizes the findings. For more information, please consult the full manuscript.

Sensitivity of commercial scanners to microchips of various frequencies

Scanner and Orientation	*125-kHz (E)*	*125-kHz (UE) (two brands)*	*128 -kHz*	*132.4-kHz (two brands)*
ResQ®, PL	100%	98.5%, 98.5%	99.6%	99.9%, 100%
ResQ®, PD	99.3%	100%, 86.5%	98.3%	99.9%, 100%
HomeAgain®, PL	99%	100%, 100%	98.1%	100%, 99.9%
HomeAgain®, PD	100%	100%, 100%	96.0%	100%, 100%
Avid, PL	100%	99.7%, 99.7%	n/a	n/a
Avid, PD	99.9%	99.7%, 99.7%	n/a	n/a
AKC CAR®, PL	53.5%	83.2%, 71.7%	99.9%	99.9%, 99.9% (detect only; did not read)
AKC CAR®, PD	81.8%	97.6%, 97.1%	99.7%	100%, 99.9% (detect only; did not read)

E=encrypted; UE=unencrypted; PL=parallel to long axis of microchip; PD=perpendicular to long axis of microchip

Lord et al's in vitro findings[9] correlated well with in vivo testing of the same scanners and microchips.[52] Scanners capable of reading 128-kHz or 134.2-kHz microchips had sensitivities ≥94.8%. Sensitivity detecting 125-kHz microchips was lower, but still was equal to or greater than 88.2%.

Scanner	***125-kHz (E)***	***125-kHz (UE) (2 brands)***	***128-kHz***	***134.2-kHz (2 brands)***
HomeAgain®	95.9%	95.6%, 93.6%	95.2%	94.8%, 98.4%
ResQ®	92.1%	97.0%, 88.2%	97.0%	98.4%, 98.4%
AKC CAR®	75.0%	66.4%, 66.6%	98.9%	95.9%, 96.8% (detect only; did not read)
Avid	98.2%	97.3%, 99.6%	n/a	n/a

Lord et al[52] also observed that every 2.3-kg increase in body weight was associated with a 5% increase in the odds that a 125-kHz microchip would be missed and an 8% increase in the odds that a 128- or 134.2-kHz microchip would be missed.

Scanning technique

Scanner performance and microchip detection can be affected by the following:[9]

- Scanning orientation (perpendicular or parallel to the long axis of the microchip);
- Distance between the microchip and scanner;
- Scanner antenna tuning (better performance with narrower frequency tuning);
- Threshold power needed to activate microchip (this depends on the power output of the scanner and the energy needed to activate the microchip);
- Variations in microchip implantation technique;
- Animal compliance during implantation and/or scanning; and
- Microchip migration.

Based on in vitro and in vivo studies, Lord et al[9,29,52] determined several criteria to maximize the efficacy of microchip scanning:

- Obtain a universal scanner that can read microchips of all frequencies with high sensitivities.
- Provide training on proper and consistent scanning technique for all personnel.
- Avoid interference by scanning away from computers, metal tables and fluorescent lighting. Remove metal collars before scanning.
- Pass the scanner over the entire animal multiple times and in different orientations, with a slightly circular or side-to-side rocking motion.
- Scan the animal more than once. In shelters, animals should be scanned at intake, at medical processing, before euthanasia and before adoption.
- Veterinary clinics should scan microchipped animals during every wellness examination to ensure microchip function.
- Develop a regular battery change schedule for the scanner to avoid detection failure. Use high-quality batteries in scanners.

Microchip registration databases

Successful tracking and reunification of lost animals with their owners also rely on accurate information within a registration database. The microchip only contains a registration number; without accurate registration associated with the microchip number, a lost, microchipped animal that is scanned might not be returned to its owner. The U.S. is the only country in which microchip implantation and microchip registration are often separate processes.[29] The lack of a centralized database in the U.S. has led to concerns of poor efficiency in reuniting lost pets with their owners.[53] Lord et al[29] determined that only 58.1% of microchipped animals were registered when animal shelters attempted to locate the animal's owner. In addition, the major reason animal shelters were unable to locate animal owners was incorrect owner information.

The American Animal Hospital Association (AAHA) created the AAHA Universal Pet Microchip Lookup Tool. The Tool, available at www.petmicrochiplookup.org, allows users to enter a microchip code and directs them to participating microchip registries associated with that microchip's number as well as the microchip's manufacturer.[54] In August 2009, Chloe Standard introduced an Internet search engine (www.checkthechip.com) that allows users to enter a microchip code and directs them to the manufacturer of the microchip.[55] The sites do not provide registration information and only provide information linking to the six microchip databases that operate in the U.S. Although a central database and/or search engine will facilitate identification of the microchip manufacturer, it is still incumbent on animal owners to register the microchip and keep the information updated.

In the U.K., the BSAVA encourages veterinarians to perform the registration to ensure completion of the process.

A survey conducted by the WSAVA in November 2002 revealed that modifications of the ISO standard identification codes had been made by a number of countries, some of which were in violation of ISO/ICAR protocol. WSAVA defined a national database as one satisfying the following criteria: industry and species neutral; national authority to administer the database; and responsible for allocating microchip identification numbers and verifying uniqueness of the numbers. Based on these criteria, a true, national database did not exist in any of the 32 countries surveyed except for France.[15]

Adverse Microchip Reactions and Biocompatibility

Transponder failures occur, but are rare. Transponder migration, although infrequent, is the most common complication associated with microchip implantation,[24,25,56,57] with the elbow and shoulder the most common locations for errant transponders in small animals.[24,25,57,58] Microchips implanted in the shoulder regions of dogs appear more likely to migrate.[59] Retrospective evaluation of 33 horses, donkeys, and mules revealed that microchips implanted in the recommended site (nuchal ligament) according to manufacturer's recommendations did not migrate and were readily detected with scanners.[1]

Microchip implantation should not be considered a substitute for proper external identification of animals.[52] Microchipped animals should also wear collars with proper identification.[30,32,33] The value of implanted microchips may be higher, and the chance of recovery improved, for cats that do not wear collars or easily escape collars.[30,32,33] Tattoos, license tags, rabies tags and personal visual identification are all components of a comprehensive pet identification program.[52]

The BSAVA instituted a microchip adverse reaction reporting system in 1996. The following table summarizes the reported types and incidences of microchip-associated adverse reactions in the United Kingdom.[56] The unified microchip registration database in the U.K, petlog, reports more than 3.7 million registered, microchipped pets.[60] The following chart summarizes the adverse reactions reported to BSAVA:[56]

Reaction	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**	**2000**	**1999**	**1998**	**1997**	**1996**
Failed			5	1	2	7	6	1	7	4	1	1	1	
Hair Loss						1								
Infection	1		1	5	1	2	1	1	1	2	1	2	1	1
Lost			3	3	7	6	6	2	3	34	7	1		
Migration	3	16	16	12	27	33	12	7	9	33	28	24	9	
Swelling		1	3	8		1	3	2	1	1	2	1		
Tumor					1		1							
Unknown		1	1	3						1	2			
Total	**4**	**18**	**29**	**32**	**38**	**50**	**29**	**13**	**21**	**75**	**41**	**29**	**11**	**1**

Implantation of transponders into the subcutaneous tissues behind the ears of 4-week old piglets produced an initial inflammatory reaction that subsided by 21 days postimplantation. A fibrous capsule formed around the microchip and remained the same thickness from 21 days until the completion of the study at 6 months postimplantation.[61] Microchip implantation in the subcutaneous tissues behind the ears of 55-week old piglets for intervals of 3 to 150 days was well accepted and produced a cellular tissue reaction that decreased with time.[62]

A study of 343 1- to 3-month old fattening calves implanted with a total of 686 injectable microchips in the ear, armpit, or upper lip revealed minimal tissue reaction surrounding the implants at slaughter 8-9 months after implantation.[63]

Animal Microchips and Cancer

Microchip transponders are commonly used to facilitate identification of individual animals in research. Inbred mice strains are commonly used in research, and tumor susceptibility varies with strain.[3,64-67]

In species or strains prone to developing tumors, an implanted microchip may induce a foreign-body reaction and tumor formation, similar to vaccine-associated sarcomas in cats.[65,68-70] The most commonly reported foreign body-induced tumors in mice and rats are fibrosarcomas, spindle-cell sarcomas, and anaplastic sarcomas.[64] Implantation of glass coverslips, plastic coverslips, or plastic coverslips with roughened surfaces underneath the skin of inbred mice (CBA/H; CBA/H-T6; C57BL/10 ScSn; and AKR/J strains) resulted in the formation of foreign body-induced sarcomas.[68] The tumor types identified were fibrosarcomas, spindle-cell sarcomas, round cell sarcomas, anaplastic sarcomas, one hemangiosarcoma, and one round-cell sarcoma with bone formation.[68] Similarly, the implantation of nonreactive materials such as platinum, stainless steel, quartz, gold, and chemically pure polymers induced tumors in mice or rats.[64]

The risk of foreign body-induced tumors is affected by duration, species (and strain), and size.[3,64] Mice and rats are more susceptible than other species to developing foreign body-induced tumors; therefore, extrapolation of increased incidences of foreign body-induced tumors in mice to increased risk in other species, including humans, is inappropriate.[64] Any foreign substance inserted into the body for long periods of time is capable of inducing neoplasia.[3,64,70] The surface texture of the foreign body affects the risk of reaction and neoplasia formation.[3,64,71,72] The surface area of the foreign body is also a factor; larger surface areas are associated with increased risk of neoplasia.[3,64] Although microchip size may vary within a narrow range, the majority of microchips used in research and companion animals in the United States are 2 mm in diameter and 12 mm in length. Therefore, the same size microchip in a mouse presents a markedly larger surface area compared to the animal’s body size than it does in a larger species such as a dog or cat; this may partially explain the species differences in the reported incidence of tumors associated with microchip implantation.

A number of studies have reported microchip-associated tumor formation in laboratory animals. However, the majority of these studies were not conducted to determine the frequency of tumor formation associated with microchip implantation alone; the tumors were observed in animals used for ongoing carcinogen and oncogenicity research, and the possible impact of the carcinogenic substances on the reported incidence of tumor formation should be considered when interpreting the studies. In addition, the microchips implanted in these animals were not the type same microchips that are implanted into pets.

Ball et al[72] reported minimal tissue reaction and an absence of tumor formation surrounding the microchip implantation sites of 40 Sprague-Dawley rats one year after implantation.

Elcock et al[3] reported a 0.7% incidence of microchip-associated tumors during two 24-month, separate chronic toxicity/oncogenicity studies using a total of 1200 Fischer 344 rats. All tumors occurred during the second year of the studies, and were mesenchymal in origin. Eight rats developed visible tumors associated with the implanted microchips, and 5 of the 8 were euthanatized due to the tumors. None of the tumors occurred in untreated, control rats in either study.

Johnson[69] reported an overall incidence of less than 1% of subcutaneous sarcomas identified in mice used for oncogenicity studies. The tumors occurred at one year post-implantation or later, and were typical of foreign body-induced sarcomas.

Following use of implanted microchips for identification of laboratory animals for more than a decade without tumor formation, one group of researchers observed an increased incidence of sarcomas in heterozygous *p53+/-* mice used for a carcinogenicity study.[67] Eighteen of 177 mice (10%) developed sarcomas at the site of microchip implantation. However, the authors cited a previous reference supporting increased susceptibility of this strain of mouse to development of sarcomas at sites of foreign body implantation. In addition, the authors stated that use of the same transponder in more than 2000 mice of a different strain (Tg.AC) over a 4-year period did not result in the formation of tumors at the implantation sites.

Thirty-six (0.8%) of 4279 implanted mice (4279 CBA/J inbred strain) developed various soft tissue tumors at microchip implantation sites during research to investigate the influence of parental preconceptual exposure to radiation or chemical carcinogens.[65] The majority of neoplasms were fibrosarcomas, but malignant fibrous histiocytomas, hemangiopericytoma-like neoplasms, and malignant schwannoma-like neoplasms were also identified. Evidence of metastasis was not observed in any of the affected animals. The frequency of tumor formation was significantly higher in females than males, but the general health of the mice was considered normal and no clinical signs were observed except nodules at the site of implantation.

The same microchip brand implanted into a different strain (B6C3F) did not induce tumor formation during a 24-month duration study.[73] Mice used in this study (140 total) were not used for concurrent carcinogenicity or oncogenicity studies. The survival rate for the study did not differ from previous noninvasive, nutritional studies. Histologic examination of tissues obtained at 3-, 15-, and 24-month necropsies revealed a fibrous capsule of varying thickness encasing the implants; no neoplastic changes were observed.

Palmer et al[66] reported fibrosarcomas associated with implanted transponders in 16 (2%) of 800 B6C3F1/CrlBR VAF/Plus mice. Four additional animals also developed fibrosarcomas, but the tumors in these mice were not associated with the implantation site. According to Rao and Edmondson,[73] the prevalence of subcutaneous sarcomas in B6C3F1 mice was reported as high as 12%. Palmer et al reported no implant-associated tumors were identified in a different strain of mice (Crl:CD-1), supporting strain-related differences in susceptibility to tumor formation.

Le Calvez et al[74] reported 4.1% of 1260 microchip-implanted mice used for 3 carcinogenicity studies developed tumors associated with the implanted transponders. The rate of tumor formation varied from one study to another, possibly reflecting an impact of the carcinogen studied. Fifty of the 52 mice that developed tumors were affected by mesenchymal tumors, and histopathologic examination of the remaining 2 tumors revealed mammary gland adenocarcinoma. The mice in these studies were B6C3F1 genetically modified mice; the authors reported a 2% baseline occurrence of these tumors within the strain population.

A microchip-associated leiomyosarcoma was reported in an Egyptian fruit bat housed in a bat conservancy.[72] The microchip was embedded in the tumor, and both were excised. The bat died during the 5th postoperative week; necropsy revealed metastatic lesions in the peritoneal cavity. The authors stated that three bats of a population of 421 microchip-implanted bats over a 14-year period developed microchip-associated complications; two developed abscesses due to poor technique, and the third developed neoplasia as described in the report. The role of previously diagnosed hemochromatosis in the development of the tumor was unknown.

Soft tissue sarcomas associated with microchips were identified in a 4-year old, female degu and a 6-year old female feathertail glider.[75] A fibrosarcoma was diagnosed in the degu 9 months following the implantation of the microchip. The feathertail glider developed osteosarcoma surrounding the microchip 5 years after implantation.

A long-term, controlled study of the effects of microchip implantation in dogs was reported, and short-term studies have demonstrated good biocompatibility and minimal tissue reaction around implanted microchips. Murasugi et al[76] evaluated the effects of microchip implantation and readability in 9 dogs up to six years after implantation. The animals were anesthetized and the implanted microchips excised at 3 days, 3 months, 12 months, or 36 months after implantation. A foreign body reaction was histologically observed following implantation, but subsided within 3 months and was followed by the formation of a fibrous capsule. The fibrous capsule was unchanged from 12 months to 72 months after implantation.

Excision and examination of microchip implantation sites from cats, obtained 21 days after implantation, showed no inflammation associated with the microchip.[77] Histopathologic evaluation of the tissues surrounding the implantation sites of a total of 90 RFID microchips for 16 weeks in 15 Beagle dogs revealed the formation of a noninflammatory, fibrous tissue capsule around 87 of the 90 implanted devices.[59]

The first report of a microchip-associated tumor in a pet was published in 2004.[71] The dog, an 11-year old male, mixed-breed dog, developed a liposarcoma at the site of a microchip implanted craniodorsally to the top of the left shoulder blade (a common site for microchip implantation as well as vaccine administration). The owner observed a small nodule at the site of implantation approximately 18 months after implantation. The nodule increased in size, and was removed 3 years after initial implantation. The microchip was embedded in the tumor. Complete surgical excision was performed, and no signs of recurrence were observed 3 months after surgery.

The findings reported by Vascellari et al in 2004[71] report were similar to those reported by McCarthy et al in 1996,[78] when an 11-year old spayed female, mixed-breed dog developed a liposarcoma associated with a glass foreign body. The authors determined the glass had become implanted when the dog had fallen from a pickup truck onto a gravel roadway 10 years prior to discovery of the mass. The foreign body and associated tumor were excised, and no tumor recurrence was observed one year after excision.[77]

The second report of a microchip-associated tumor was published by the Vascellari et al[70] in 2006. A 9-year old, male French Bulldog developed a subcutaneous mass near the site of microchip implantation and vaccine administration approximately 8 months prior to tumor development. Histopathologic evaluation revealed infiltrative fibrosarcoma, similar to postinjection sarcomas observed in cats. In contrast to the prior case, the microchip in this case was attached to, but not embedded in, the tumor; based on the findings, the authors were unable to determine if the tumor was induced by the implanted microchip, rabies vaccines, or a combination of factors. Microchips are often implanted in sites commonly used for subcutaneous injection of vaccines; this further complicates efforts to establish a direct causal link between microchips and adverse reactions (including tumors).

Daly et al[79] reported fibrosarcoma formation adjacent to an implanted microchip in a 14-year old cat. Similar to the case described above, the tumor was adjacent to, not embedded in, the tumor. Because the cat had also received numerous vaccines in the same area, the authors could not determine the origin of the fibrosarcoma. Treatment of the fibrosarcoma was multimodal, including preoperative radiation therapy and surgical resection of the mass. Histopathological evaluation of the excised mass revealed a lack of reaction around the microchip; this finding supports the likelihood that the proximity of the microchip to the tumor was coincidental, and the tumor was not induced by the presence of the implanted microchip. The report underscores the importance of following vaccination site recommendations, as described by the American Association of Feline Practitioners, to reduce the risk of sarcoma formation.

In the 13 years since inception of the BSAVA's microchip adverse reaction program, 2 tumors have been reported[56] despite microchip implantation in more than 3.7 million pets in the United Kingdom.[56,60] The WSAVA Microchip Committee concluded that the benefits of microchip implantation far outweighed the potential health risks.[15]

For More Information:
American Veterinary Medical Association
Coalition for Reuniting Pets and Families
World Small Animal Veterinary Association
British Small Animal Veterinary Association

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