



Molecular Cloning and Expression Analysis of *Vps26A* Gene from Deer Antler Tip of Different Growth Stages

Yanling Xia^{1,2}, Heping Li², Yuntao Liang², Jichen Zhao², Binshan Lu² and Di Liu^{1,*}

¹Heilongjiang Academy of Agricultural Sciences, Postdoctoral Programme, Harbin 150086, China

²College of Wildlife Resources, Northeast Forestry University, 26 Hexing Road, Harbin 150040, China

Yanling Xia and Heping Li contributed equally to this work.

ABSTRACT

Retromer complex plays a crucial role in retrograde transport of the recycle proteins from the endosome to Golgi, and Vps26A protein is an important component of the retromer complex. In the present study cDNA sequence of the full coding region of the *Vps26A* gene was successfully cloned from antler tip of the Sika deer (*Cervus nippon hortulorum*). The *Vps26A* cDNA contains an open reading frame of 984bp encoding a polypeptide with 327 amino acids. The deduced molecular mass and isoelectric point of Vps26A protein were 38.2 kDa and 6.13, respectively. Glutamic acid had the largest proportion (10.4%) in the primary structure. Homologous sequence alignment and phylogenetic tree analysis indicated that the Vps26A protein of sika deer was highly similar to that of *Bos taurus*. Expression analysis by real-time quantitative RT-PCR revealed that *Vps26A* gene had a higher expression level at day 90 than those obtained at day 60 and 30.

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Authors' Contribution

YX and DL designed the experiment. HL collected the tissue samples. YL performed the experiment. JZ and BL analyzed the data. YX wrote the article.

Key words

Antler, *Vps26A* gene, Cloning, Real-time quantitative RT-PCR.

INTRODUCTION

Antlers are bony appendages of the deer head which are the only organ of regeneration in Mammals. Antlers are male secondary sexual characteristic which regularly cast and re-grow each year. The developing antlers are covered with velvet-like skin which grow at the fastest rate among all the mammalian organs/tissues. Antler growth process is divided into growth period and ossification period. In the growing period the maximal elongation rate can be up to 1-2 cm per day, which is more rapid than the growth rate of any mammal bone tissue. The growth rate of antler tip cells is 30 times faster than that of a tumor cell, however displays no sign of canceration. Thus, it has attracted a great deal of attention by many scientists (Brookes and Kumar, 2005; Odelberg, 2005; Price and Allen, 2004). It is an ideal tissue/sample for studying the proliferation, growth and differentiation of mammalian cells. The development of antlers is co-regulated by some genes. Thus, defining the expression properties of the genes would lead to a deeper understanding of deer antler growth and development mechanisms.

Vps26A protein is a component of the retromer complex which is a peripheral membrane protein complex. The mammalian retromer complex consists of SNX1/2, SNX5/6, Vps26, Vps29 and Vps35 (Brookes and Kumar, 2005). The retromer complex is essential for normal cell function, and it is involved in recycling of the proteins from the endosomes to trans-Golgi network or plasma membrane. Functionally, the retromer has been linked to prominent neurodegenerative diseases such as Alzheimer's and Parkinson's (Trousdale and Kim, 2015; Wang and Bellen, 2015; Small and Petsko, 2015). Some studies also show that the retromer complex is involved in some specific developmental processes (Wang and Bellen, 2015).

In the present study, we have successfully cloned the sequence of full coding region of *Vps26A* gene in the reserve mesenchyme of antler tip samples, and studied the expression levels in different growth periods. The results provide a basis for further study of biological function of the *Vps26A* gene and provides a theoretical foundation for subsequent investigations perhaps in the field of cancer therapy for mammals.

MATERIALS AND METHODS

Collection of tissue samples

The tips of growing antler (about 30, 60 and 90 days)

* Corresponding author: nkydl63@sina.com

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Fig. 1. Deer antlers from different growth periods. A, deer antler of 30 days; B, deer antler of 60 days; C, deer antler of 90 days.

were collected from an adult sika deer. 30 days sample was the left antler tip, 60 days sample was the right antler tip and when the left antler tip continued to grow to three branched velvet antler was used as 90 days sample (Fig. 1). The distal 5 cm of the tips were removed, and reserve mesenchyme was collected (Li *et al.*, 2002). Samples were immediately preserved in liquid nitrogen.

Total RNA isolation

Total RNA was extracted from samples obtained in different growing periods by using TRIZOL reagent (Invitrogen, America) as instructed in its manual. DNA content of the extract was removed by incubating the total RNA with RNase-free DNase I (Promega, America) at 37°C for 30min. The total RNAs were electrophoresed in 1.0% agarose gel for 20 min. First-strand cDNA synthesis was performed using M-MLV reverse transcriptase (Rever Tra Ace - α - TM, Japan) with oligod (T) 20.

Amplification of *Vps26A* cDNA

Briefly, based on analysis of the conservative amino acid sequences, the primers pair (F- primer: 5'-AATGAGTTTTCTTGGAGGA-3' and R-primer: 5'-CAAACCTAAATCTCAACGG-3') was designed to amplify cDNA of *Vps26A* gene according to *Vps26A* gene sequences in homologous species. The RT-PCR was performed using the primers and cDNA sample produced from the tissue samples in rapid growing period. Positive colonies of *Vps26A* gene were selected to carry out PCR identification, bacterial amplification and sequencing.

Bioinformatics analysis

Homology of the cloned sequence was analysed by using the NCBI BLAST facility. The *Vps26A* gene sequence was analyzed and compared using the BLAST

and ORF search programs in the GenBank database. The multiple sequences alignment of *Vps26A* protein set was performed with DNASTar7.10. The signal peptide site was predicted by Signal P3.0, and the *Vps26A* protein MW and PI were computed by ProtParam tool. A phylogenetic tree based on evolutionary distances was constructed from amino acid sequences with MEGA 6.0 using the neighbor-joining method.

Expression analysis of *Vps26A* gene

The expression pattern of *Vps26A* gene in different developmental periods was examined by quantitative real-time polymerase chain reaction. QRT-PCR analysis was performed by using a SYBR Premix EX TaqTM II (TaKaRa, Japan) on a Chromo 4 Real-Time PCR Detector (BIO-RAD, USA). In the real-time RT-PCR study, specific primers (*Vps26A*-F: 5'-TTTTTGGTCCCATTGTGAGA-3' and *Vps26A*-R: 5'-GCCTCTTCCAGGTTGCTT-3') were used to amplify a 168bp fragment with the cDNA from reserve mesenchyme of different growth periods. β -Actin was used as a the reference (β -Actin-F: 5'-GCGTGACATCAAGGAGAAGC-3' and β -Actin-R: 5'-GGAAGGACGGCTGGAAGA-3', 173bp). PCR reaction was performed in a total volume of 25 μ L containing 12.5 μ L 2 $\times$ SYBR Green Master Mix (TARAKA), 1.5 μ L (each) *Vps26A*-F and *Vps26A*-R primers (10 mM), 2 μ L template, and 7.5 μ L DEPC-water. The thermal profile for SYBR Green real-time PCR was 95 °C for 30s, followed by 40 cycles of 95 °C for 30 s, and 58 °C for 30 s, and 72 °C for 1 min. Each sample was performed in three technical replicates. DEPC-water for the replacement of template was used as negative control. The relative expression was calculated according to $2^{-\Delta\Delta C_t}$ method (Livak and Schmittgen, 2001; Zhai, 2017).

ATGAGTTTTCTTGGAGGATTTTTTGGTCCCATTTGTGAGATCGACGTTGTCCTTAATGA	60
M S F L G G F F G P I C E I D V V L N D	
TGGGGAAACCAGGAAAATGGCGGAAATGAAACTGAAGATGGCAAAGTAGAAAAGCACTA	120
G E T R K M A E M K T E D G K V E K H Y	
TCTTTTCTATGATGGAGAATCTGTTTCAGGAAAGGTGAACCTAGCCTTTAAGCAACCTGG	180
L F Y D G E S V S G K V N L A F K Q P G	
AAAGAGGCTAGAGCACCAAGGAATTAGAATTGAATTTGTAGGTCAAATTGAGCTTTTCAA	240
K R L E H Q G I R I E F V G Q I E L F N	
TGACAAGAGTAATACTCACGAATTTGTAAACCTAGTGAAAGAACTAGCCTTACCTGGAGA	300
D K S N T H E F V N L V K E L A L P G E	
ACTGACTCAGAGCAGAAGTTATGATTTTGAATTTATGCAAGTTGAAAAGCCATATGAATC	360
L T Q S R S Y D F E F M Q V E K P Y E S	
TTACATCGGTGCCAATGTCCGCTTAAGGTATTTTCTTAAAGTGACAATAGTAAGAAGACT	420
Y I G A N V R L R Y F L K V T I V R R L	
GACAGACTTGGTAAAAGAATATGATCTTATTGTTCCACAGCTTGCTACCTATCCTGATGT	480
T D L V K E Y D L I V H Q L A T Y P D V	
CAACAACCTCTATTAAGATGGAAGTGGGCATTGAAGATTGTCTACACATTGAATTTGAATA	540
N N S I K M E V G I E D C L H I E F E Y	
TAATAAATCAAAGTATCATTAAAGGATGTGATTGTTGGAAAAATTTACTTCTTATTAGT	600
N K S K Y H L K D V I V G K I Y F L L V	
AAGAATAAAAAATCCAACATATGGAGTTACAACCTGATTAAGAAAGAGATCACAGGAATTGG	660
R I K I Q H M E L Q L I K K E I T G I G	
ACCCAGTACCACAACAGAAACAGAAACAATTGCTAAATATGAAATAATGGATGGTGCACC	720
P S T T T E T E T I A K Y E I M D G A P	
AGTTAAAGGTGAATCAATTCCAATAAGACTATTTTTAGCAGGATATGACCCAACCTCCAAC	780
V K G E S I P I R L F L A G Y D P T P T	
AATGAGAGATGTGAACAAAAAATTTTCAAGTAAAGTACTTTTTGAATCTAGTCCTTGTGTA	840
M R D V N K K F S V R Y F L N L V L V D	
TGAAGAAGACGAAGGTACTTCAAGCAGCAGGAGATCATTTTGTGGAGAAAAGCTCCTGA	900
E E D R R Y F K Q Q E I I L W R K A P E	
AAAACCTGAGGAAAACAGAGAACAACCTTTTCAACAGCGATTGTAATCACCAGAATCACAGGC	960
K L R K Q R T N F H Q R F E S P E S Q A	
ATCTGCTGAGCAGCCTGAAATGTGAACCTGAATGGGAGAAAAAAGAAAAAACCCTC	1020
S A E Q P E M . T E W E K K K E K K T S	
CTATACCCGTTGAGATTTAGGTTTG	1045
Y T R . D L G L	

Fig. 2. Nucleotide and deduced amino acid sequences of Vps26A cDNA from sika deer (ATG is the initiation codon; * is the stop codon).

RESULTS AND DISCUSSION

Sequencing and bioinformatics analysis of Vps26A gene

The *Vps26A* gene encodes a polypeptide of 327 amino acids (Fig. 2). The calculated molecular mass of the mature protein is 38.2 kDa and isoelectric point is 6.13. Vps26A protein belongs to non-secretory protein without signal peptide. Sequence analysis revealed that the putative amino acid sequence of Vps26A is very similar to the other Vps26A proteins from other species (Fig. 3). Based on the amino acid sequences of Vps26A proteins, a phylogenetic tree was constructed using the neighbor-joining method (Fig. 4), which showed that Vps26A of sika deer was mostly related to *Bos taurus*, whereas it was most distant to *Gallus gallus* and *Alligator sinensis*. The

analysis was consistent with the order of those species in the traditional taxonomy. Homology analysis showed that Vps26A proteins are highly conserved among different species. It implies that *Vps26A* gene would be an important stabilizing agent for various cell function.

Expression analysis of Vps26A gene

Differences in the expression level of Vps26A mRNA was detected in different periods (about 30, 60, 90 days). Day 60 is equivalent to the rapid growth period and day 90 is equivalent to the ossification period. Result showed that the gene has the lowest expression level in day 30. In the other periods, 60 days 1.32, 90 days 2.00 (Fig. 5), indicating that the gene may play a regulatory role in cartilage formation.

	***** ***:**:* ***,***** **:******:*****:.. ** *
Mus	MSFLGGFFGPICEIDVALNDGETRMAEMKTEDGKVEKHLYFYDGESVSGKVNLAFAKQPG 60
Panthera	GSFLGGFFGPICEIDVVLNDGETRMAEMKTEDGKVEKHLYFYDGESVSGKVNLAFAKQPG 60
Equus	MSFLGGFFGPICEVDVVLNDGETRMAEMKTEDGKVEKHLYFYDGESVSGKVNLAFAKQPG 60
Bos	MSFLGGFFGPICEIDVVLNDGETRMAEMKTEDGKVEKHLYFYDGESVSGKVNLAFAKQPG 60
Cervus	MSFLGGFFGPICEIDVVLNDGETRMAEMKTEDGKVEKHLYFYDGESVSGKVNLAFAKQPG 60
Orcinus	MSFLGGFFGPICEIDVVLNDGETRMAEMKTEDGKVEKHLYFYDGESVSGKVNLAFAKQSG 60
Ovis	LSFLGGFFGPICEIDVVLNDGETRMAEMKTEDGKVEKHLYFYDGESVSGKVNVAFAKQPG 60
Gallus	MSFLGGFFGPVCEIDVILNDAETRKAEMKTEDGKVEKHLYFYDGESVSGKVNVS-KQQG 59
Alligator	MSFLGGFFGPVCEIDVILNDAETRKAETKTEDGKVEKHLYFYDGESVSGKVNICFKQQG 60

Mus	KRLEHQGIRIEFVGQIELFNDKSNTHFVNLVKELALPGELTQSRSYDFEFMQVEKPYES 120
Panthera	KRLEHQGIRIEFVGQIELFNDKSNTHFVNLVKELALPGELTQSRSYDFEFMQVEKPYES 120
Equus	KRLEHQGIRIEFVGQIELFNDKSNTHFVNLVKELALPGELTQSRSYDFEFMQVEKPYES 120
Bos	KRLEHQGIRIEFVGQIELFNDKSNTHFVNLVKELALPGELTQSRSYDFEFMQVEKPYES 120
Cervus	KRLEHQGIRIEFVGQIELFNDKSNTHFVNLVKELALPGELTQSRSYDFEFMQVEKPYES 120
Orcinus	KRLEHQGIRIEFVGQIELFNDKSNTHFVNLVKELALPGELTQSRSYDFEFMQVEKPYES 120
Ovis	KRLEHQGIRIEFVGQIELFNDKSNTHFVNLVKELALPGELTQSRSYDFEFMQVEKPYES 120
Gallus	KRLEHQGIRIEFVGQIELFNDKSNTHFVNLVKELALPGELTQSRSYDFEFMQVEKPYES 119
Alligator	KRLEHQGIRIEFVGQIELFNDKSNTHFVNLVKELALPGELTQSRSYDFEFMQVEKPYES 120

Mus	YIGANVRLRYFLKVTIVRRLTDLVKEYDLIVHQLATYPDVNNISIKMEVGIEDCLHIEFEY 180
Panthera	YIGANVRLRYFLKVTIVRRLTDLVKEYDLIVHQLATYPDVNNISIKMEVGIEDCLHIEFEY 180
Equus	YIGANVRLRYFLKVTIVRRLTDLVKEYDLIVHQLATYPDVNNISIKMEVGIEDCLHIEFEY 180
Bos	YIGANVRLRYFLKVTIVRRLTDLVKEYDLIVHQLATYPDVNNISIKMEVGIEDCLHIEFEY 180
Cervus	YIGANVRLRYFLKVTIVRRLTDLVKEYDLIVHQLATYPDVNNISIKMEVGIEDCLHIEFEY 180
Orcinus	YIGANVRLRYFLKVTIVRRLTDLVKEYDLIVHQLATYPDVNNISIKMEVGIEDCLHIEFEY 180
Ovis	YIGANVRLRYFLKVTIVRRLTDLVKEYDLIVHQLATYPDVNNISIKMEVGIEDCLHIEFEY 180
Gallus	YIGANVRLRYFLKVTIVRRLSDIVKEYDLIVHQLATYPDVNNISIKMEVGIEDCLHIEFEY 179
Alligator	YIGANVRLRYFLKVTIVRRLSDLVKEYDLIVHQLATYPDVNNISIKMEVGIEDCLHIEFEY 180

Mus	NKSKYHLKDVI VGKIYFLLVRIKIQHMELQLIKKEITGIGPSTTTTETI AKYEIMDGAP 240
Panthera	NKSKYHLKDVI VGKIYFLLVRIKIQHMELQLIKKEITGIGPSTTTTETI AKYEIMDGAP 240
Equus	NKSKYHLKDVI VGKIYFLLVRIKIQHMELQLIKKEITGIGPSTTTTETI AKYEIMDGAP 240
Bos	NKSKYHLKDVI VGKIYFLLVRIKIQHMELQLIKKEITGIGPSTTTTETI AKYEIMDGAP 240
Cervus	NKSKYHLKDVI VGKIYFLLVRIKIQHMELQLIKKEITGIGPSTTTTETI AKYEIMDGAP 240
Orcinus	NKSKYHLKDVI VGKIYFLLVRIKIQHMELQLIKKEITGIGPSTTTTETI AKYEIMDGAP 240
Ovis	NKSKYHLKDVI VGKIYFLLVRIKIQHMELQLIKKEITGIGPSTTTTETI AKYEIMDGAP 240
Gallus	NKSKYHLKDVI VGKIYFLLVRIKIQHMELQLIKKEITGIGPSTTTTETI AKYEIMDGAP 239
Alligator	NKSKYHLKDVI VGKIYFLLVRIKIQHMELQLIKKEITGIGPSTTTTETI AKYEIMDGAP 240

Mus	VKGESIPIRLFLAGYDPTPTMRDVNKKF SVRYFLNLVLVDEEDRRYFKQQEII LWRKAPE 300
Panthera	VKGESIPIRLFLAGYDPTPTMRDVNKKF SVRYFLNLVLVDEEDRRYFKQQEII LWRKAPE 300
Equus	VKGESIPIRLFLAGYDPTPTMRDVNKKF SVRYFLNLVLVDEEDRRYFKQQEII LWRKAPE 300
Bos	VKGESIPIRLFLAGYDPTPTMRDVNKKF SVRYFLNLVLVDEEDRRYFKQQEII LWRKAPE 300
Cervus	VKGESIPIRLFLAGYDPTPTMRDVNKKF SVRYFLNLVLVDEEDRRYFKQQEII LWRKAPE 300
Orcinus	VKGESIPIRLFLAGYDPTPTMRDVNKKF SVRYFLNLVLVDEEDRRYFKQQEII LWRKAPE 300
Ovis	VKGESIPIRLFLAGYDPTPTMRDVNKKF SVRYFLNLVLVDEEDRRYFKQQEII LWRKAPE 300
Gallus	VKGESIPIRLFLAGYDPTPTMRDVNKKF SVRYFLNLVLVDEEDRRYFKQQEII LWRKAPE 299
Alligator	VKGESIPIRLFLAGYDPTPTMRDVNKKF SVRYFLNLVLVDEEDRRYFKQQEII LWRKAPE 300
*****:*****	
Mus	KLRKQRTNFHQRFESPD SQASAEQPEM 327
Panthera	KLRKQRTNFHQRFESPD SQASAEQPEM 327
Equus	KLRKQRTNFHQRFESPD SQASAEQPEM 327
Bos	KLRKQRTNFHQRFESPD SQASAEQPEM 327
Cervus	KLRKQRTNFHQRFESPD SQASAEQPEM 327
Orcinus	KLRKQRTNFHQRFESPD SQASAEQPEM 327
Ovis	KLRKQRTNFHQRFESPD SQASAEQPEM 327
Gallus	KLRKQRTNFHQRFESPD SQASAEQPEM 326
Alligator	KLRKQRTNFHQRFESPD SQASAEQPEM 327

Fig. 3. Multiple alignment of *Vps26A* protein sequences from different species.

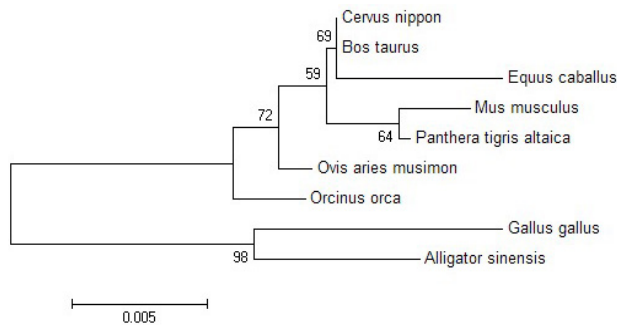


Fig. 4. The phylogenetic tree of Vps26A proteins from different species. Phylogenetic analysis based on the Vps26A amino acid sequences from various animals. The phylogenetic tree for the Vps26A proteins was constructed using the neighbor-joining method. The origins and accession numbers of the Vps26A sequences were: *Bos taurus* (NP_001068923.1); *Equus caballus* (XP_005613841.1); *Mus musculus* (NP_598433.1); *Panthera tigris altaica* (XP_015399148); *Ovis aries musimon* (XP_011980964.1); *Orcinus orca* (XP_004280845.1); *Alligator sinensis* (XP_006023201.1); *Gallus gallus* (XP_421577.2).

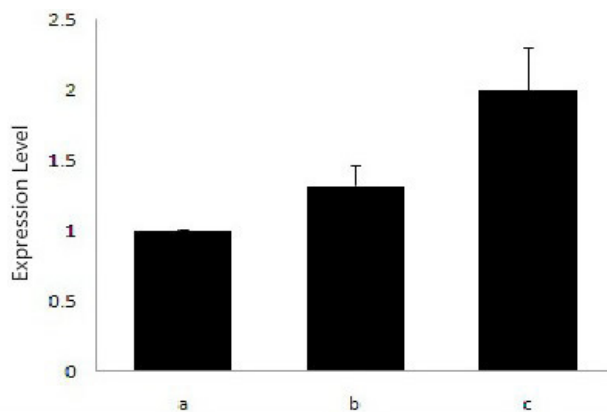


Fig. 5. Expression of *Vps26A* gene in different growth periods from sika deer antler. a, 30 days; b, 60 days; c, 90 days.

Retromer, consisting of two biochemically distinct sub-complexes, regulates the retrieval of cargo from endocytic system to TGN (Seaman *et al.*, 1998; Harbour *et al.*, 2010). Vps26A protein is a component of the retromer complex. Retromer complex is highly conserved among various eukaryotes including mammals and plants composed of similar subunits (Oliviussun *et al.*, 2006; Shimada *et al.*, 2006). The core retromer complex, consisting of trimer of Vps26, Vps29 and Vps35 recognizes the membrane bound receptor whereas the SNX sub-complex helps it to associate with the membrane (Arighi *et al.*, 2004;

Bonifacino and Hurley, 2008). Vps26 of mammalian cells contain two paralogues of the protein, Vps26A and Vps26B, and they bind to different retromer cargo molecules (Bugarcic *et al.*, 2011; Kerr *et al.*, 2005). But Vps26A is more important than Vps26B since it has greater range of binding partners and the greater severity of defects seen in cells without Vps26A (Trousdale and Kim, 2015).

The Retromer complex is involved in the Wnt signaling pathway by Wntless which is a kind of WNT signaling receptor. Recently, some studies have identified the Wntless and retromer complex as important components of the WNT signaling pathway. In the absence of retromer, Wntless is degraded in lysosomes and Wnt secretion is impaired (Eaton, 2008). Previous researches have already showed that Wnt signaling plays an important role in the early development of animal embryos, organ formation, tissue regeneration and other physiological processes. Wnt signaling pathway can significantly promote the proliferation of rat mesenchymal stem cells *in vitro* (Olivares-Navarrete *et al.*, 2011), and the Wnt signaling pathway plays an important role in the osteogenic differentiation of mesenchymal stem cells (Yang *et al.*, 2003). In addition, the retromer complex is essential for removal of the apoptotic cells. Retromer plays a role in the regulation of CED-1 which is mediated by retromer from phagocytosis to the surface of the phagocytic cells membrane. Without retromer complex, CED-1 will be transported to the lysosomal and degraded during the apoptotic process of the cell (Collins, 2008).

The results of the present study indicated that the expression level of *Vps26A* gene in reserve mesenchyme varies significantly during the development. The expression level of *Vps26A* gene was up-regulated in the process of growth and development of deer antler. *Vps26A* gene has a higher expression level at 90 days than 30 days and 60 days. It may be proposed that the gene plays an important role in cartilage development process. As a component of the retromer complex, the Vps26A may also be related to the clearance of apoptotic cells. However, specific mechanisms associated with these functions require further research.

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Statement of conflict of interest

Authors have declared no conflict of interest.

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