Figure S1: Primer sequence

Primer name	Primer sequence（5‘-3’）	Primer function
sox11a-g1-F	TGTAATACGACTCACTATA ggtcgctttatgtgtccgg GTTTTAGAGCTAGAAAT	gRNA synthesis
sox11a-g2-F	TGTAATACGACTCACTATA ggctgtcttgcaccagtct GTTTTAGAGCTAGAAAT	
sox11b-g1-F	TGTAATACGACTCACTATA gggtcgtttgatgtggccgg GTTTTAGAGCTAGAAAT	
sox11b-g2-F	TGTAATACGACTCACTATA gggtcgtttgatgtggccgg GTTTTAGAGCTAGAAAT	
gRNA-R	AAAAAAAGCACCGACTCGGTGCCAC	
sox11a-F	ACTTCGCCTCCTCCGCGCAA	real-time PCR
sox11a-R	AGCCCAGGCTGCCCTCGCTA	
sox11b-F	ATGGCTGACTACCCCGACT	
sox11b-R	GCTGCTTTGACACTTTTGC	
p2rx4b-F	CTTTGGAATCCGCTTTGACG	
p2rx4b-R	AGGTTAAGAAGGGCAAGAGC	
calhm2-F	GTGATTGAACGCCAGCTACA	
calhm2-R	TATGCCTCCTGCTGATAGCC	
mctp2b-F	CTCCAGAGTGCCCTCAGATA	
mctp2b-R	GCACCTTCACACAGACTGAT	
rcn3-F	ATAATGAAGCCCGGCATCTC	
rcn3-R	TTTGGTGAGATCCTCTCCGT	
s100a11-F	ACAAGCTTGGTCAAATCCCA	
s100a11-R	AGAACTCCATGAACGTCAGC	
chrm2a-F	TGTCCAGCATCATGTCCTCA	
chrm2a-R	AGGTACAGCCACTCAGATCG	
slc8a4a-F	AAGAAGAGGTGGCCAAGATG	
slc8a4a-R	CAGCGCAAGGTTAGTCTTCT	
aldh7a1-F	GAAGAGTGTTCCGCTGGTTA	
aldh7a1-R	CAAACGCTCCTCCAATCTCA	
matn1-F	TTGCCAAGAAGCTGCAAATC	
matn1-R	CTCTTCGTCACAGCTTCCAA	
and1-F	CTGATCCGCAACAGGAGAAA	
and1-R	CTCTGCAACTCCGTCTTTGT	
crtap-F	AAATTTGGCCTCGACGATGA	
crtap-R	GGCATGAACTTCTGTTTGGC	
dlx4a-F	ATCCAGGAGCTTACCTACCC	

dlx4a-R	CGTTCAGCCGTATTTCTCCA	
twist1a-F	GTCAACATCCCACTAACGCA	
twist1a-R	CTCCTTCCAGTGAGTTCAGC	
twist1b-F	TTCTCGGTTTGGAGGATGGA	
twist1b-R	AGCTCACGGTTTGACCATTT	
sec23a-F	CCCGAGTATGAGAACTTCCG	
sec23a-R	CGTGCTCAGTGTCGATGTAG	
osc-F	ATCAGCTGACACAGAAGCGA	
osc-R	GGCGGTGATGATTCCAGACG	
runx2a-F	GACCATGGTGGAGATCATAGC	
runx2a-R	GGGTTCGTGAATACTGTGATTG	
runx2b-F	AGAGCTTCACCCTGACGATTAC	
runx2b-R	AGGTACGATGGGTATGTCTGGT	
ctsk-F	GTAACGAGAGGGCACTGAC	
ctsk-R	TTCCTTGTTGCAGTTTGGGT	
entpd5a-F	TGAAGAGTGGAGCTTTGGTG	
entpd5a-R	GATGCTGCTTCCTTTGACCT	
col1a1a-F	TCTGCTGGATCAGCTGGTAA	
col1a1a-R	CAATTTCTCCATTGCGACCAC	
akt2-F	AAGAAGCTCGTTCCACCCTT	
akt2-R	GGTCTGTGCAGTGAACTCAT	
atp6v1h-F	CAGGTTATTGCCGTCGCA	
atp6v1h-R	TGTTTACCACCCAGCTGTTC	
β-*actin*-F	ATGCCCCTCGTGCTGTTTTC	
β-*actin*-R	GCCTCATCTCCCACATAGGA	
Probe-*and1*-F	GATGTACCTGCAGCACCTTG	Probe synthesis
Probe-*and1*-R	TAATACGACTCACTATAGGG CATACCCGACGAAACATTCA	
Probe-*crtap*-F	CTTTTCCGTTTGCGTCC	
Probe-*crtap*-R	TAATACGACTCACTATAGGG ACTGCGTTCTTCAGGTCATT	
Probe-*sec23a*-F	ACCAGCCTGCTGAGCTACTT	
Probe-*sec23a*-R	TAATACGACTCACTATAGGG TCCCTGCTAATGCCATTTTA	
Probe-*col10a1a*-F	ACCAGCCTTACTCCGTGAAA	
Probe-*col10a1a*-R	TAATACGACTCACTATAGGG TCCAGGTTTCCCTGAAGGTC	
sox11a-HMRA-F1	TGATGAAAGCGAATTCATGG	Genotyping
sox11a-HMRA-R1	CTGGAGACTGTTCCATGATC	
sox11b-HMRA-F1	CGAGGAGAGCGAAATGATGGCTTG	
sox11b-HMRA-R1	CGCATTCATGGGTCGTTTGATGTG	

Figure S2: The conservation of *sox11* in various species.

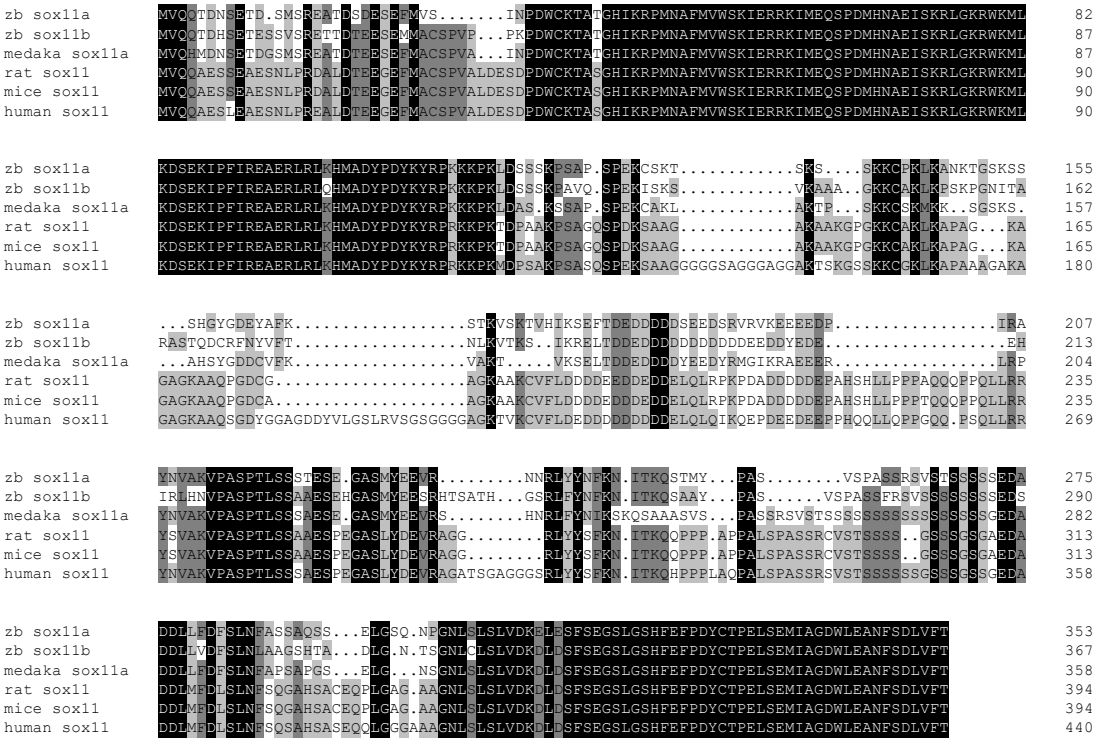

Figure S3: The second line of *sox11a*$^{m/m}$ mutant and *sox11b*$^{m/m}$ mutant

A: The target site of *sox11a*$^{m/m}$ mutant line.

CTCGATAAACCCAGACTGGTGCAAGACAGCCACCGGACACATA

CTCGATAAACCCAGAC----------AGCCACCGGACACATA -11bp

B: The amino sequence of Sox11a

M V Q Q T D N S E T D S M S R E A T D S D E S E F M V S I N P D W C K T A T
G H I K R P M N A F M V W S K I E R R K I M E Q S P D M H N A E I S K R L G
K R W K M L K D S E K I P F I R E A E R L R L K H M A D Y P D Y K Y R P K K
K P K L D S S S K P S A P S P E K C S K T S K S S K K C P K L K A N K T G S K
S S S H G Y G D E Y A F K S T K V S K T V H I K S E F T D E D D D D D S E E D
S R V R V K E E E E E D P I R A Y N V A K V P A S P T L S S S T E S E G A S M Y E
E V R N N R L Y Y N F K N I T K Q S T M Y P A S V S P A S S R S V S T S S S S S
E D A D D L L F D F S L N F A S S A Q S S E L G S Q N P G N L S L S L V D K E
L E S F S E G S L G S H F E F P D Y C T P E L S E M I A G D W L E A N F S D L V
F T Y *

C: A frameshift mutation of *sox11a*$^{m/m}$ mutant

M V Q Q T D N S E T D S M S R E A T D S D E S E F M V S I N P D S H R T H K
A T D E R V H G V V *

D: The target site of *sox11b*$^{m/m}$ mutant line.

GGTGCCACCGAAACCGGACTGGTGCAAGACAGCCACCGGCCACAT

GGTGCCACCGAAACCG--ACTGGTGCAAGACAGCCACCGGCCACAT -1bp

E: The amino sequence of Sox11b

M V Q Q T D H S E T E S S V S R E T T D T E E S E M M A C S P V P P K P D W C K T A T G H I K R P M N A F Met V W S K I E R R K I M E Q S P D M H N A E I S K R L G K R W K M L K D S E K I P F I R E A E R L R L Q H M A D Y P D Y K Y R P K K K P K L D S S S K P A V Q S P E K I S K S V K A A A G K K C A K L K P S K P G N I T A R A S T Q D C R F N Y V F T N L K V T K S I K R E L T D D E D D D D D D D D D D E E D D Y E D E E E H I R L H N V P A S P T L S S A A E S E H G A S M Y E E S R H T S A T H G S R L F Y N F K N I T K Q S A A Y P A S V S P A S S F R S V S S S S S S S S S E D S D D L L V D F S L N L A A G S H T A D L G N T S G N L C L S L V D K D L D S F S E G S L G S H F E F P D Y C T P E L S E M I A G D W L E A N F S D L V F T Y *

F: A frameshift mutation of *sox11b*$^{m/m}$ mutant

M V Q Q T D H S E T E S S V S R E T T D T E E S E **M M** A C S P V P P K P T G A R Q P P A T S N D P *****

Figure S4: The production process of *sox11a*$^{m/m}$*sox11b*$^{m/m}$ double mutant.

sox11a$^{+/+}$*sox11b*$^{+/+}$	*sox11a*$^{+/+}$*sox11b*$^{m/+}$	*sox11a*$^{m/+}$*sox11b*$^{+/+}$	*sox11a*$^{m/+}$*sox11b*$^{m/+}$
sox11a$^{+/+}$*sox11b*$^{m/+}$	*sox11a*$^{+/+}$*sox11b*$^{m/m}$	*sox11a*$^{m/+}$*sox11b*$^{m/+}$	*sox11a*$^{m/+}$*sox11b*$^{m/m}$
sox11a$^{m/+}$*sox11b*$^{+/+}$	*sox11a*$^{m/+}$*sox11b*$^{m/+}$	*sox11a*$^{m/m}$*sox11b*$^{+/+}$	*sox11a*$^{m/m}$*sox11b*$^{m/+}$
sox11a$^{m/+}$*sox11b*$^{m/+}$	*sox11a*$^{m/+}$*sox11b*$^{m/m}$	*sox11a*$^{m/m}$*sox11b*$^{m/+}$	*sox11a*$^{m/m}$*sox11b*$^{m/m}$

Figure S5: The ratio of *sox11a*$^{m/m}$ mutant with curved spine (*****P*<0.0001).**

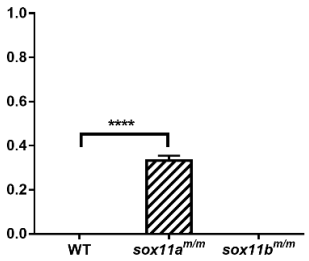

Figure S6: The expression level of *sox11a* in WT and *sox11b*$^{m/m}$ mutant (P*<0.05).**

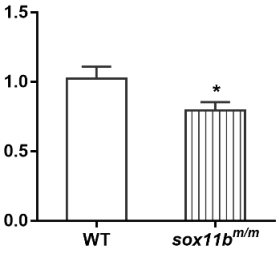

Figure S7: The expression level of *sox11b* in WT and *sox11a*$^{m/m}$ mutant (P<0.01).**